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Screw Thread Practice

THE matters upon which the National Screw Thread Commission, recently created by Congress, have been working are of fundamental importance to the automotive industry. **The Commission has recently** issued a progress report of its work, tentative recommendations being made therein as to screw, bolt, nut and pipe thread standards, classification of fits, allowances (prescribed differences in dimensions, the limits of which are prescribed) and tolerances (definite differences in dimensions prescribed).

The Commission is composed of nine members. The Chairman of the Commission is the Director of the Bureau of Standards. The Army and the Navy have each designated two representatives. The four remaining members of the Commission were nominated by the Society of Automotive Engineers and the American Society of Mechanical Engineers. The act establishing the Commission defined as its purpose the ascertaining and establishing of standards for screw threads for use in the various branches of the Federal Government and for the use of manufacturers. The Commission has made a very comprehensive and creditable report on systems of threads, together with information, data and specifications pertaining to the manufacture of the threads recommended.

Too much emphasis cannot be placed on the fact that the specification and maintenance of proper manufacturing tolerances in any factory have everything to do with attaining economical production and quality of product. It has been recognized that as a class the automotive shops of this country are unexcelled in production work in general.

Under the act creating it, the Commission is to report back to Congress and to the Secretaries of War, Navy and Commerce. The act provides that the standards, when accepted and approved by the Secretaries of War, Navy and Commerce, are to be adopted in the several manufacturing plants under the control of the War and Navy Departments and so far as practicable in all specifications for screw threads, in proposals for manufactured articles, parts or materials to be used under the direction of these departments, and furthermore, that the Secretary of Commerce shall promulgate such standards for use by the public.

The Society held a meeting in September, which was attended by various representatives of passenger-car, motor-truck, screw, bolt and nut and gage manufacturers, as well as representatives of the Army and of the Bureau of Standards. A general discussion was had on most of the important points involved in the screw thread standardization. It should be borne in mind that while, heretofore, there have been screw standards, such as the U.S. Standard, the A.S.M.E. Standard and the S.A.E. Standard, and pipe standards such as the Briggs, there have never yet been generally adopted or promulgated in a general way necessary features of screw thread practice, like allowance, limits or tolerance or a method of specifying the features described (that is whether maximum screw or minimum nut diameter). Neither have these latter methods been interpreted in the same way by even the best manufacturers in the automotive field. Much has been learned in manufacture during the war and fundamental methods are being changed as a consequence both here and abroad. There is nothing more important to the automotive industry than that this whole matter shall be clarified as far as possible and settled correctly to the fullest possible extent.

The Society is securing the best information of a comprehensive nature as to what is most desirable in screw thread practice in the automotive industry. Reports have been made on the work of the National Screw Thread Commission, and data secured during the recent visit of the Commission to Great Britain and France have been submitted. At the September S. A. E. session, at which President Charles M. Manly presided, the following were present: Morris Thomson, Timken Detroit Axle Co.; Paul W. Abbott, Lincoln Motor Co.; Lyle K. Snell, Willys-Overland Co.; R. P. Smith, Packard Motor Car Co.; W. A. Davidson, Singer Mfg. Co.; Alexander Taub, General Motors Co.; William Beckman, Duesenberg Motors Co.; Calvin W. Rice, secretary American Society of Mechanical Engineers; E. H. Ehrman, Chicago Screw Co.; W. R. Porter, S. S. White Dental Mfg. Co.; C. M. Pond, Pratt & Whitney Co.; A. W. Erdman, Pratt & Whitney Co.; Lieut.-Col. E. C. Peck, Ordnance Department; Earle Buckingham, Pratt & Whitney Co. and Niles-Bement-Pond Co.; B. H. Blood, Pratt & Whitney Co.; L. A. Fischer, Bureau of Standards; J. B. Thomas, Westinghouse Electric & Mfg. Co.; W. K. Jamison, Domestic Engineering Co.; L. P. Kalb, Standard Parts Co., and E. Burdsall, Russell, Burdsall & Ward Bolt and Nut Co.

INFORMATION FROM MANUFACTURERS

It was decided that to accomplish the most of value to the automotive industry and to secure the best consensus of opinion for consideration in national or international screw thread standardization, the best procedure would be to gather from representative manufacturers in practical shop form definite information as to present practice. When all is said and done the minutiæ of screw

thread practice are among the most obscure things in industry, and while at the present time there is an advanced stage in this connection, there is still room for great improvement, speaking generally. The S. A. E. special committee to direct the collection and analysis of the industrial data mentioned is composed of Paul W. Abbott, chairman, Lincoln Motor Co.; R. P. Smith, Packard Motor Car Co.; Lyle K. Snell, Willys-Overland Co.; Alexander Taub, General Motors Co., and W. K. Jamison, Domestic Engineering Co.

Representatives of the Society are, of course, in close touch with the work of the National Screw Thread Commission. They are also well informed on the matters involved in possible international screw thread standardization, in which authoritative bodies of Great Britain and France have evinced considerable interest. These countries, together with the United States, are responsible for a very large portion of the world's screw thread production. Adequate and precise knowledge as to the manufacture and measurement of screw threads is too narrowly confined. As has been emphasized by Lieut.-Col. E. C. Peck, who has served as a representative of the Army on the National Screw Thread Commission and was acting chairman of the Commission during its recent visit to Europe, strict interchangeability consists in making the different parts of a mechanism so uniform in size and contour that each part will fit and function properly in any one of the whole number of mechanisms, no matter when or where it is made. Each part of the mechanism of a certain model will fit any of the mechanisms of the same model, regardless of the lot to which it belongs or the year in which it was made. If the quantities being manufactured are large, interchangeable manufacture is economical because it entails a correct system of gaging as well as of manufacture. Successful manufacture of good quality product at low cost requires skill, ability and experience of a high order. In strictly interchangeable manufacture it is necessary to have standards for comparison to reproduce dimensions or obtain a uniform size of part at any time.

One of the fundamental issues in the broad screw thread standardization relates to the so-called standard hole practice as distinguished from making maximum screw size basic in the specification of dimensions with tolerances. An outline of the points of advantage advanced for each system was given in THE JOURNAL for February of this year on page 95. It is argued that fundamentally it is the best practice to have the minimum dimensions of the external or receiving member standard. In the special inquiry of the S. A. E. Committee the automotive manufacturers are being asked to state specifically whether they make the minimum nut or the internal thread pitch diameters basic size, or the maximum screw or external thread pitch diameters basic size. In fact, comprehensive data are in process of collection in the whole matter, including such points as how much above or below basic size internal and external thread pitch diameters are made if they are not made basic; what modifications of the United States Standard form of thread are used, if any; how much over theoretical tap drill size holes are drilled for tapping; to what extent special pitches are used, that is other than those specified in the U. S., S. A. E. and A. S. M. E. standards; whether the maximum pitch diameters of external threads cross or interfere with the minimum pitch diameters of the internal threads; limits allowed on internal and external thread pitch diameters; oversize on pitch diameter of studs for tight fit in cast iron, steel or aluminum; whether taps are purchased commercially or ordered specially to specified limits; the gage system used and specification of the detail of same, including the amount of wear before discarding.

Establishment of Standards

The Society could hardly conduct a more important work than that looking toward the clarification of the many complexities of screw thread practice, the establishment as standard of detail practice data, the preparation and dissemination of information relating thereto and the maintenance in automotive manufacture of methods relating to screw threads which will facilitate economical production, improve quality and maintain the essential element in the whole matter, namely interchangeability. The best intelligence must be exercised in the determination of the points necessarily involved in commercial interchangeability. As a finality, before production can reach its highest stage of economy and efficiency, the dimensions which shall be basic will have to be determined, together with the allowable deviation from precise measurement for each class of fit. A great many matters are involved in screw, bolt, nut and pipe threads. In addition to the matter of "minimum nut basic" or "maximum screw basic," there is the question whether the master gage tolerance should be included in the maximum tolerance specified for the work. A view has been advanced that parallel threads should not be used for tight fits. In any event, it is a fact not generally appreciated, that the specification of thread limits has everything to do with the success of a factory. It is a maxim that proper limits should be specified and then absolutely adhered to. The specification of wrong limits or failure to maintain correct limits when specified, results in financial loss unbelievable by any except those who know. Speaking colloquially, good or bad practice in this respect makes or breaks a company.

The report of the National Screw Thread Commission as tentatively made is a document of great value, containing detail data of a remarkably comprehensive nature. The Commission has held another public hearing this month which will, perhaps, be the last one prior to the issuance of its report in final form. It is the duty of the industry at this time to give immediate and sufficient attention to the questions involved, with the vital purpose of arriving at results concordant with the best consensus of opinion of those qualified to direct design and production of automotive apparatus so far as screw threads are concerned. There have been, and are, surprisingly few known well-equipped screw thread specialists in this country or abroad. Work in this field is, of course, to a great extent a specialty. Apparatus designers have to a very great extent failed to familiarize themselves with the intricacies of screw thread practice, with the result that there has been deplorable confusion between designing and production departments, and it is a great task to collect, collate and analyze data adequate for necessary and highly desirable decisions as to standard practice in general. A little thought makes clear that those things which are everybody's business are neglected from the standpoint of prompt advance which is the crux of development and progress.

In the work at this time the Society is having the assistance in the collection of data of manufacturers associations in the automotive field, such as the National Automobile Chamber of Commerce, the Motor and Accessory Manufacturers Association, the Manufacturers Aircraft Association, the National Association of Engine and Boat Manufacturers, the National Gas Engine Association and the National Implement and Vehicle Association.

Development of the Ordnance Four-Wheel-Drive Truck

By L. C. FREEMAN[1] (*Member*)

METROPOLITAN SECTION PAPER *Illustrated with* PHOTOGRAPHS

SHORTLY after the United States became involved in the recent war, the necessity for a powerful heavy-duty truck with power in all four wheels became apparent. The Ordnance Department saw the necessity of making a study of the problem and developing a vehicle particularly adapted to conditions where the service was unusually severe. We were requested to make a thorough study of the four-wheel-drive situation in general and under the supervision of the Ordnance Department to design and develop models. These models finally evolved into the standardized ordnance four-wheel-drive truck, and the modified form called the artillery wheeled tractor. This work was started in the Ordnance Department but was later transferred to the Motor Transport Corps.

While we had ideas as to what a four-wheel-drive vehicle should be, it was desirable to obtain all the advice and to take advantage of all the specialized experience possible, and I wish to acknowledge the invaluable assistance given by consulting engineers, production men, parts makers and truck manufacturers, outside of our own organization. The makers of existing four-wheel-drive trucks gave us the benefit of their experience, their engineers checking over and criticizing the designs and advancing many suggestions that were adopted.

Elaborate and continuous tests were conducted of all the best-known makes of four-wheel-drive vehicle built in this country, and Latil and Renault tractors were shipped over from France and made available for this purpose. These tests consisted in part of running the trucks over a given course as many hours out of the 24 as possible, this course including good and bad roads and hilly and level country; accurate reports being kept on findings.

PREPARATION OF SPECIFICATIONS

After this work had been carried on for some time, two sets of specifications were developed from a fundamental standpoint, covering mainly the operating requirements and giving no consideration at this period as to how these requirements were to be met. These specifications showed that the vehicle should have the following characteristics:

(1) High clearance
(2) Light weight
(3) Short turning radius
(4) Short front overhang
(5) High tractive ability
(6) Low center of gravity
(7) Short overall length

The fundamental requirements were submitted to various authorities, both military and civil, and finally boiled down as just mentioned. We then arrived at the point where it was possible to work up tentative specifications for the design of a vehicle to meet these requirements. In working up the specifications, due to the exigencies of the war, the prime considerations had to be first, production possibilities and second, maximum interchangeability, not only in the vehicle itself but with other existing vehicles.

At this point three rules were laid down for guidance in the work which followed.

These were, first, that the construction throughout should be conventional, no untried feature being allowed, it being obviously no time for experiments. Second, that the construction should be symmetrical. This decision was reached after considerable discussion and was made from the standpoint that a symmetrical arrangement of parts more nearly coincides with the best accepted engineering practice of vehicles in general, that it would furnish a more flexible construction with which to meet unknown conditions which might arise in the future, and finally, that symmetry means interchangeability. Third, that as each problem was met, it should be considered basically, and all available talent specializing in that particular problem called in for consultation, and that where specialists were called in, their suggestions should be adopted or they should be convinced that the construction used was, all things considered, the better one.

The problem then became one of adapting existing production facilities and well-known units to a construction that would meet the desired operating requirements. Naturally, this condition tended to complicate greatly the giving of the proper value to each of the multitude of variable factors which entered into and affected the solution of the problem. It was the unanimous opinion that the driver should be placed in the conventional position back of the engine because thereby the maximum of accessibility and the best placing and proportioning of all parts could be obtained. This is obvious when it is remembered that in the years of evolution of the motor-car industry millions of dollars have been expended, thousands of the best brains in the world have been concentrated on the problem of development and hundreds of different makers, starting with every conceivable construction, have, without any definite cooperation, finally arrived at a conventional construction which gives the best results from the standpoint of distribution of material and weight, accessibility of parts and production possibilities.

The first fundamental requisite, high clearance, necessitated the use of internal-gear drive axles, which, in view of the policy of using no untried construction, meant placing the differential on top of the axle. It follows then that we had the option of placing the engine and driver in one of three positions relative to the axle, entirely behind, over or entirely in front. As the

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third arrangement best met the fundamental operating requirements, it was adopted.

The first thought was to adapt the "Quartermaster B" engine to this vehicle, but upon investigation it was found that it would considerably increase the front overhang, and would have a material effect on the weight of the vehicle, which was limited by military requirements. To be specific, it would have meant an increase of about 6 in. in the overhang, and roughly 350 lb. additional weight. The next choice, therefore, fell upon an engine of about the same displacement, which was already in use in large quantities in the Army in other vehicles. The radiator was located back of the engine to reduce the front overhang further. This location is moreover advantageous from the standpoint of radiator protection.

As the Hele-Shaw clutch was already satisfactorily in use in connection with this engine in a large number of Army vehicles, it naturally followed that it should be adopted. The transmission presented a considerable problem, as our calculations showed the necessity of four speeds with an unusually low first speed, and as the service of a truck of this kind entails a large amount of gear usage, it was necessary to provide an unusually sturdy transmission. This problem was finally met by the adoption of the Quartermaster B transmission with a special low-gear reduction.

Determination of Gear Ratios

In a four-wheel drive all the weight is available for traction, while in a rear-drive truck usually not more than 80 per cent of the total weight can be so used. Therefore, if the Government specification for the low-gear tractive ability of rear-drive trucks is correct, it should be 25 per cent greater for a four-wheel drive, if both vehicles are to be able to spin their wheels under the same conditions. This is true regardless of load distribution but assumes a uniform coefficient of friction and locked differentials. The low-gear tractive ability for rear-drive trucks was specified as 0.338; following the reasoning mentioned this figure should be 0.4225 for a four-wheel drive, assuming the same end efficiency of 70 in each case. In a four-wheel drive the tractive ability of the vehicle is equal to the maximum coefficient of friction against which the tires can be slipped, while the tractive ability multiplied by the weight, minus the resistance to motion of the vehicle itself, equals the maximum drawbar pull.

Taking 0.4225 as the desired tractive ability and the gross weight as 16,000 lb., the tractive effort necessary becomes 6760 lb. With an engine torque of 2580 lb.-in., an end efficiency of 70 and 40-in. wheels, this necessitates a low-gear ratio of 74.86 to 1. As it was desired to limit the engine speed to 1200 r.p.m. at 15 m.p.h., the high-gear ratio was therefore found to be about 9.5 and the transmission low-gear ratio should be approximately 7.85 to 1. These ratios were modified by structural considerations to 9.6 to 1 on high gear and 73.6 to 1 on low gear, with a transmission low-gear ratio of 7.66 to 1, giving a truck speed on high gear of 15 m.p.h. with an engine speed of 1210 r.p.m.

As the ratio of weight available for traction to total weight was for rear-wheel drives taken as 80 per cent maximum, the derived tractive ability for four-wheel drives is therefore a minimum. The transfer case was therefore made so as to permit the reversal of driving and driven sprockets or the substitution of others, with resulting low-gear reductions of 86.6 or 95.1 to 1, with corresponding reduction in maximum truck speed. This lower ratio gives a tractive ability of about 0.43 with a 5-ton load. Actually a drawbar pull of 9000 lb. can be steadily maintained under these conditions.

The changing of the gears in the transmission did not present as great a problem as it might be expected, but an attempt to incorporate the transfer case with the transmission would have meant an entirely new design. After serious consideration, it was decided to make the transfer case a separate, independent unit, not only to keep the transmission intact, but to provide a more flexible construction and greater serviceability. The transfer case in itself presented a big problem, and all the various possible constructions were carefully considered. Of the various methods and suggestions there were but two which were considered practical, gears and silent chain. Our calculations showed the gears to be undesirable from the standpoint of tooth speed, while the chains used in other vehicles were non-adjustable. Both types of construction were built and tested out. That with the gears verified our figures, inasmuch as it was impossible to make them quiet. It was much larger in size and made for additional weight. This is a good example of the flexibility obtained by symmetrical construction, because while the gears drove the propeller-shafts in the opposite direction from the chain construction, the symmetrical proportioning allowed us merely to reverse the differential housings on the axles, leaving us free to use either type desired without change of parts, other than the transfer unit itself. The chain-driven transfer unit was provided with an adjustment, allowing the chain to be used for a great many more miles of service, and this construction proved satisfactory and was finally adopted. Further, by the use of a separate unit transfer, it was possible to locate this in the chassis so that the universal-joints and propeller-shafts to the front axle were identical with those to the rear.

Universal-Joints for Driving

Of all the various methods suggested of driving the wheels, but two were found to be practical, bevel gears or universal-joints. The bevel-gear construction is naturally more complicated, due to bearings required, etc. There is an additional loss of power in these gears, as there is also a loss of power through the universal-joints when driving through an angle. This, however, led to a very interesting finding, that in a given amount of driving, the steering-wheels are at an appreciable angle only about 2 per cent of the time; and as there is practically no loss of power in the universal-joints when driving straight ahead and the construction is simpler, this method of driving was adopted.

The next step after having decided to use universal-joints was to determine precisely what type should be employed. It was desirable to use a conventional universal-joint, and as the angle through which we wished to operate these joints reduced our factor of safety to practically zero, a double-joint construction was developed. Later tests of over 25,000 miles proved this judgment to be sound, as in no case did any joint show appreciable wear. In this connection there was developed, also, a new type of oil-retaining housing, which did not rotate with the joint, although accommodating itself to the various positions of the joint as the wheels were turned.

As all problems were considered basically, that of supporting the steering driving pinion was attacked from the standpoint of providing suitable bearings for

the purpose. The usual construction is that the outer pinion bearing is made sufficiently small that the internal gear in the wheel can be slipped off over it, with the result that this bearing is often overloaded and fails. We, therefore, provided suitably large bearings and made the removal of the wheel a separate problem. With suitable bearings and proportioning of other parts, the wheel has to be removed infrequently, usually to replace the tire. It was, therefore, allowable to use a construction requiring the unbolting of the flange of the driving pinion support, dropping this slightly, and in this way allowing the wheel to be demounted.

The differential housings were made identical for both front and rear axles, and, principally to maintain the desired road clearance from tire to tire, the brakes were located on each side of the differential housing, the driving members being proportioned to withstand braking strains. This also eliminated the objectionable

The Flexibility of Construction Is Tested by Some Rough Going

feature of the usual construction of oil leakage on the brakes when too much lubricant was applied to the internal gears. In this vehicle little lubricant was required on the internal gear for long periods of time, there being no appreciable leakage except in case of overcharging. It is interesting to note at this point that throughout all the severe tests to which these vehicles were put, in deep mud and heavy sand, no grit found its way into the gears, nor was there any appreciable wearing of the gears during the thousands of miles of test to which they were subjected.

As a four-wheel-drive truck is often called upon to operate over very rough ground, considerable care was taken to prevent the power-transmitting units from being affected by frame distortion. To this end real three-point suspensions were evolved, the rear end of the engine, for example, being carried on what was practically a full universal-joint.

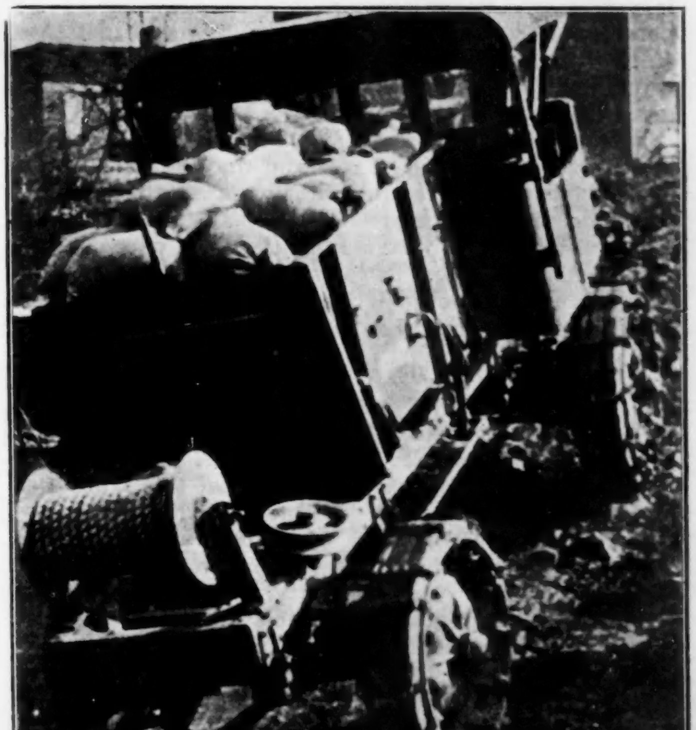
Drive and torque were taken through the springs, all four of which had both eyes wrapped, and were symmetrical as well as interchangeable, so that a spring could be used at the front or the rear and put on with

Towing a 3-Ton French Tractor and a Second Truck with a 2-Ton Pay Load up a Dirt Road Having a 15 Per Cent Grade

either end forward. The design of the shackles followed very closely that of the Quartermaster B truck and employed the same magazine system of oil lubrication.

Use of Ordinary Units

But three of the main units, axles, transfer case and radiator, were new, all the others, either exactly as used or in a slightly modified form, being in commercial practice in other vehicles. As to internal interchange-



Climbing a 45 Per Cent Grade with a 5-Ton Pay Load

ability, the following incomplete list indicates what was accomplished:

(1) All four wheels and bearings are alike
(2) All four springs are interchangeable and can be mounted either end forward
(3) All five brakes are interchangeable
(4) Differential housing assemblies on both axles are identical
(5) The driving-shafts on the front axle are interchangeable
(6) The driving-shafts on the rear axle are interchangeable
(7) Front and rear propeller-shafts are interchangeable
(8) All three differentials are the same
(9) Transfer sprockets are interchangeable, allowing the use of different gear ratios for various kinds of service
(10) All spring bolts and shackles are alike

The winch is designed to break a $1\frac{1}{2}$-in. new manila rope. On the samples we had tested this required a pull of 17,000 lb., or somewhat in excess of the handbook figures. As the winch head diameter was 16 in. this necessitated a turning moment on its shaft of 136,000 lb.-in. and a reduction relative to the engine of about 60 to 1. Part of this was obtained by using a standard 3-ton axle worm and wheel with a ratio of $10\frac{1}{3}$ to 1. The drive was from the extended transmission countershaft, the remainder of the required reduction being obtained by gears mounted on and housed in the transfer case arm.

In conclusion, the commercial field which the four-wheel-drive truck may claim for its own, widens upon closer view. Its province has been regarded as beginning where the two-wheel drive leaves off and ending where the caterpillar begins. It is believed that this is not by any means a comprehensive statement of its possibilities and that it can and will compete successfully in certain applications not only with the track layer but also with the heavier sizes, at least, of rear-drive trucks.

It should be remembered that the power is distributed to four wheels instead of two and that while there are more parts, they are duplicates and smaller, as the stress on many of them is lower than on corresponding parts of rear-drive trucks of the same capacity.

As to the gasoline consumption, tire mileage and maintenance cost, even if based on mileage instead of work done, the rear drive should look to its laurels.

The Discussion

C. T. Myers:—With reference to points which came up in the design work, there was a great argument over the steering-gear. The four-wheel-drive truck is hard to steer at best, and it seemed that this truck was going to be a rather difficult one for a man to handle. The drivers always complained of four-wheel-drive trucks, but by getting a special gear reduction in the steering-gear that was very largely overcome in this case. The steering-gear is a double drag link construction with a floating connection. It involves four steering-balls on the arms instead of two.

The manner in which the cooling was handled is also worthy of commendation. The radiator placed behind the engine rides much more easily than in the overhung position. This installation was worked out in an entirely new way, and aside from a little trouble with whistling of the air going through, which was obviated, we attained good cooling. The engine is not an easy one to cool, but I never heard any complaint as to the radiator.

We were all greatly concerned about the weight. It ran considerably over the figure that had been fixed as a maximum, but it was a question, I believe, of being sure that everything was sturdy enough to do the job. I believe 9000 lb. was the limit, whereas the job actually weighed something over 10,300 lb. I think the feeling was that that was a really good job.

L. G. Nilson:—I would like to ask the type of differential.

L. C. Freeman:—They were all locking or so-called friction differentials, all three being exactly alike.

W. E. Perrine:—Why are there three differentials on a four-wheel-steering truck? Theoretically the front and rear wheels should turn at the same speed because they both describe the same respective circles. Why was the internal gear instead of the external gear used and why was the differential bolted to the axle instead of to the frame with flexible axle shafts as on the De Dion? Was the fabric universal-joint tried, and if so with what results? Why were the front and rear axle jack-shafts not interchangeable? It seems to me that if the differentials, the wheels, springs, etc., were interchangeable the axle jack-shafts might have been.

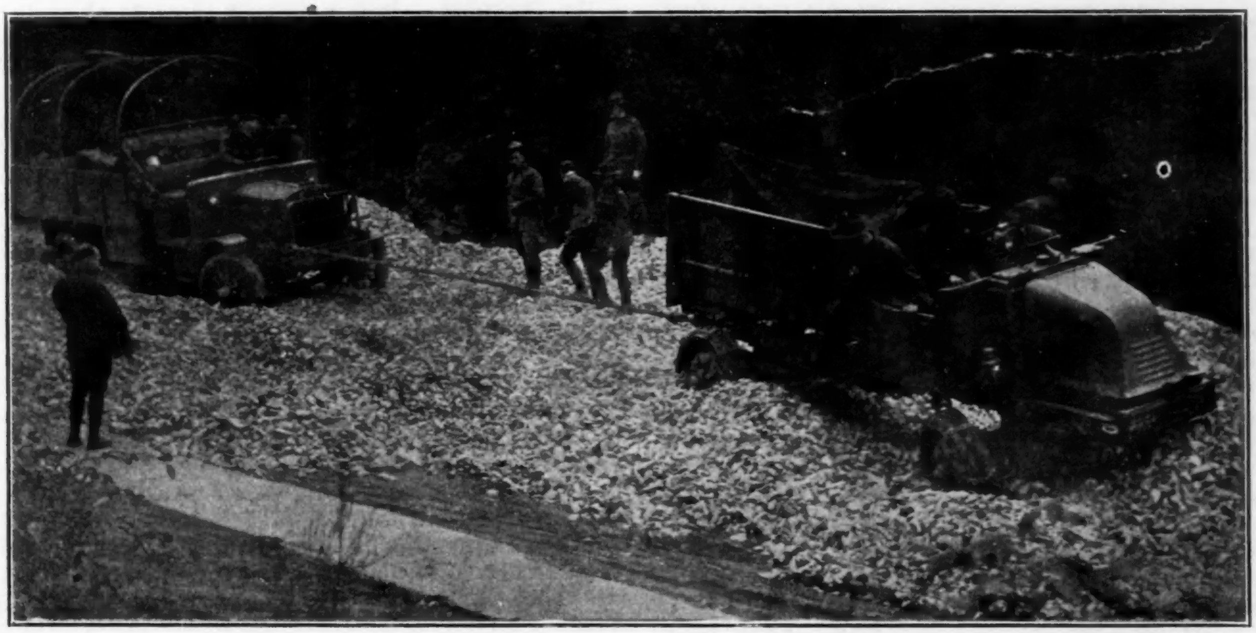
G. W. Dunham:—The Militor truck steers with two wheels only. There is a modified form known as the artillery wheeled tractor which steers with all four wheels. This was done to obtain a 35-ft. turning radius for military purposes. The two-wheel-steer truck holds the road much better. It has about the same turning radius as any truck of like capacity.

Three differentials are used, one in each axle and one in the center to equalize the effort applied to the axles. A two-differential construction was considered, but we were working under high pressure with little time for experimentation. It was our aim to adhere closely to correct engineering. Obviously, if the various stresses are to be taken care of properly, three differentials are necessary. With two-wheel steering there is considerable differentiation in axle speeds when turning a corner. This is eliminated in four-wheel-steering vehicles but regardless of whether it is two or four-wheel steering, there is a very appreciable difference in axle speeds when going straight ahead over rough terrain. If one pair of wheels climbs over a high obstruction, and the rear wheels travel on the level, the middle differential is necessary if unnecessary stresses are to be eliminated. Undoubtedly this correct or full application of differentials has much to do with the large drawbar ability of the job. On reasonably good roads 8000-lb. drawbar pull is easily maintained.

The internal-gear drive-axle construction was used for two purposes. First, it gave the maximum ground clearance, and, second, it was the simplest construction that would allow of applying power to the steering-wheels and yet provide the degree of interchangeability desired.

The differential assembly could be bolted to the frame as well as to the axle, but the former construction is considerably more complicated and would have introduced more universal-joints into a structure already generously supplied with them. This problem should be considered from the standpoint that the unsprung weight could be reduced by putting the differential assembly on the frame, but that would have penalized the construction by greater mechanical complication. The unsprung weight with the construction as it stands is not objectionable. The structure is the most simple, accessible and interchangeable

possible to obtain. I have heard some discussion recently to the effect that heavy-duty internal-gear drive axles with the differential assembly supported on the axle center should have some slight universal action between the differential assembly and the driving pinion in the wheel. This was considered while the axles were being developed, and it was decided that if the I-beam was made reasonably strong there would not be sufficient movement between the differential housing and driving pinion to warrant the additional complication. Our judgment in this has been confirmed to the extent that the test trucks which have run over 25,000 miles show no appreciable wear, and from the fact that the six vehicles which were put through the most severe tests have developed absolutely no faults of any kind in the running gear, with the exception of one of the first axles which



Towing Another Truck with a 3-Ton Load Through 3 Ft. of Crushed Stone and Carrying 3 Tons Besides

was made out of cast steel and put under the truck temporarily until forgings could be obtained. One of these axles had a permanent set underneath the spring-seat on account of a very large flaw at that point, which easily reduced the strength of the axle 80 per cent.

Two types of transfer case were tested. Many types were considered, but the whole proposition was eventually boiled down to gears versus silent chain. The latter had been used in thousands of four-wheel-drive vehicles but was more or less unsatisfactory, as there was no provision for adjustment. We were skeptical as to the results to be obtained with gears on account of the high tooth speed required. It was also feared that difficulty would be experienced in getting the gears reasonably quiet. Therefore both types were built and tested out. We were unable to get the gears to run quietly, and as the chain with its adjustable feature proved satisfactory from the first, the gear construction was soon dropped.

We did not try fabric universal-joints as we wanted all the universal-joints to be as nearly alike as possible, and obviously the fabric joint was not adaptable to the extreme angles required for steering purposes.

The front and rear-axle jack-shafts were interchangeable on the four-wheel-steer truck; the front and rear axles were identical to the last detail. But with the two-wheel-steer truck a simpler and cheaper rear construction was obtained by eliminating the steering joints. There seems to be a tendency on the part of many who have probably never had intimate contact with four-wheel-drive vehicles to feel that there is some sort of mysterious condition in the four-wheel-drive construction which has to be overcome in some unusual way. I rather felt that way about it myself before I got into the problem. In reality, there is no problem in the four-wheel-drive construction that is not satisfactorily solved in the two-wheel-drive type. The transfer case and the flexible drive to the steering-wheels came as near presenting new problems as anything. Everything else in the two types of vehicles is identical. For example, let us take a conventional two-wheel-drive truck with an internal-gear drive axle, locate the differential assembly on the top of the I-beam instead of at the side, and place this axle under the front end of the truck, moving the engine forward to provide clearance for the differential assembly. Aside from the transfer case and steering universal-joints mentioned, the conventional two-wheel-drive truck has become a four-wheel drive so far as all problems are concerned.

To get power to the new front axle it is necessary to provide a transfer case in the center of the truck with a propeller-shaft to the front axle. I think we can dispose of the transfer case by saying that it is a very simple structure consisting of two parallel shafts, four bearings, two sprockets, a silent chain and a case. There only needs to be proper proportioning to carry the loads, and upon analysis no mysterious features can be found. The problem of obtaining flexible driving-shafts to the steering wheel is another case of adapting an old construction to a new idea. As has been proved by our tests, previously referred to, we have solved this by the use of double universal-joints. After 25,000 miles of severe service no appreciable wear could be detected. No trouble was experienced with any of the trucks at any time. There is nothing in the four-wheel-drive vehicle that has not already been solved in the two-wheel-drive.

As to the use of the truck with power in all four wheels, within certain limitations trucks and passenger

cars of the two-wheel-drive type undoubtedly perform satisfactorily in every respect, but where severe conditions are met these limitations soon became most evident and annoying. Where the road surface is reasonably smooth, the hills not excessively steep and the loads to be carried not extreme, there is no doubt that a two-wheel-drive vehicle will do about all that one could ask, but on the other hand the vehicle with power in all four wheels will do this same work and much more besides. It will negotiate steeper hills, handle trailers to better advantage and travel over rougher roads and softer ground under adverse conditions, as during snowstorms, long after the two-wheel drive has ceased to operate. Examples of the ability of a vehicle with power in all four wheels are carrying the commercially rated pay load, 5 tons, up a 40 per cent grade, without unusual effort; hauling twice the commercially rated load and a trailer up a 16½ per cent grade, well within its maximum effort. If the law had not prohibited the use of more than one trailer on the test hill, Fort Lee, the trailer would have handled another trailer with a second 5 tons. Is there not a need for this additional ability? Of course there is and more besides.

There are really three kinds of work vehicles: two-wheel-drive which will carry all sorts of loads under fairly good conditions, track-laying tractors built to negotiate ground on which all other types of vehicle have failed and the truck with power in all four wheels which will do the work of the two-wheel-drive vehicle and extend up through the range of operations well into the field covered by the track-layer. The track-laying tractor will do anything that either of the wheeled vehicles can accomplish in the way of moving freight and more, but it is handicapped and made undesirable in most cases for cargo carrying through lack of speed.

There is another popular misunderstanding in regard to the four-wheel-drive vehicle, it being the general feeling that the fuel consumption must be excessive and the cost of maintenance high. While the rating from a military standpoint is 3 tons, the truck under discussion is in reality a strong 5-ton commercial vehicle. From tests covering thousands of miles it has been found that the average fuel consumption is about 3 to 3½ miles per gallon of gasoline. In these tests a number of different makes of two-wheel-drive vehicle were used, and it has been our experience that the maintenance on the Militor was no more, and in some cases appreciably less, than that on the two-wheel-drive vehicles. Further, so far as we have been able to ascertain from others using large fleets of trucks, the mileage and maintenance are better, if anything, than in the case of most two-wheel-drive jobs.

A. L. KIMBALL:—I believe everybody is very much interested in the locking differential, and I would like to know with what type the greatest success was had and how many miles they found it stood up without failure.

MR. DUNHAM:—The differential used was the M & S. As to the number of miles it would stand up, I can only say that one of the trucks which I examined recently has been driven over 25,000 miles, and the differentials are practically as good as they were the day they were put in. It was definitely decided originally that a self-locking differential should be used. In investigating the possibilities we found this type of differential had been used in a large number of Government vehicles, and that while they wore out somewhat too rapidly, practically no other criticism as to their performance could be found. An analysis of the problem showed that the differentials already in use were overloaded, so that a proportionately larger differential was used with the results just mentioned.

GEORGE NEWBOLD:—I would like to ask whether an extensive test to obtain an accurate comparison of the total efficiency between a four-wheel drive and rear-wheel drive was made. In the city of New York with two trucks of as nearly equal capacity as possible, do you find any hope for the four-wheel drive in total efficiency?

MR. DUNHAM:—In what terms do you want to express that, in fuel economy and maintenance?

MR. NEWBOLD:—In total efficiency. For instance, a four-wheel drive has equal distribution of traction and less wear on the parts, etc., but how about the total efficiency taking everything into account. Do you think there is hope for a four-wheel drive as against a rear-wheel drive?

MR. DUNHAM:—It is a difficult thing to show conclusively. I can answer perhaps in this way. In so far as fuel consumption, labor for maintenance and tire mileage are concerned, it is our impression from talking with people operating large fleets of two-wheel-drive vehicles of like capacity, that there is not very much difference one way or the other. The fact that you have four power wheels, the tires of which total considerably greater capacity than is found on a corresponding size of rear-drive vehicle, obviously makes the work on the tires comparatively easier. I know that our tests showed excellent results. The labor for maintenance through all the tests has been very reasonable. One of the trucks made a trip loaded from Washington to St. Paul, Minn., and back to New York. At St. Paul the truck was looked over, the carbon removed, the valves ground and the brakes adjusted. Aside from that and the difficulty experienced one day with a stoppage in the gasoline line, no difficulty of any nature was encountered.

Comparing the two types of vehicles, I am impressed with the feeling that there is little difference one way or the other, with the exception of the initial cost. A vehicle of a given capacity with power in all four wheels must of course cost more than one with a two-wheel drive. There are certain things which offset that difference in cost, except perhaps where the service is comparatively light; namely, ability to operate the year round regardless of weather or road conditions, to ascend very steep grades when loaded, and unusual ability to handle heavy loaded trailers.

MR. NEWBOLD:—You spoke of heavy duty. Do you mean pulling trailers?

MR. DUNHAM:—Pulling trailers, negotiating unusually bad going, climbing hills, etc.

MR. NEWBOLD:—Is it necessary to have a trailer to do this?

MR. DUNHAM:—The truck will naturally carry a load on its back and perform without a trailer up to its carrying capacity, providing the ground is not so soft that the wheels will sink in and mire. With the trailer greater loads can be carried, as the unit pressure is of course much reduced.

MR. PERRINE:—With a locking differential is it not true that each driving axle must be capable of taking the whole drive? We find in using locking differentials or axles with no differential that the ordinary axle designed to take a balanced load through the differential is apt to give trouble owing to the overload of individual shafts when taking the entire drive, when the opposite wheel is in a slippery place. The same thing, it seems to me, would be true with a four-wheel drive with a locking

differential, throwing the entire load on a front or rear axle when the other axle was without traction.

Mr. Dunham:—That is a hard thing to talk about, because with the data available you cannot prove your contention, but I can tell you what I think about it. If any one of the driving wheels were positively connected through gearing to the engine, that is, if all differentials were locked up solid and the various parts were proportioned the same as at present, there is no doubt that certain weak points would develop, but that condition is an impossible one. It comes right back to a similar condition as to the low first speed in a transmission. Theoretically, with a very low first speed the engine should twist the live axles and a number of other parts subjected to the enormous torque, but where trucks have been equipped with low first speeds, this condition does not come about. The explanation of both the low first-speed condition and the self-locking differential not twisting the live axles is in my estimation that there are two sorts of stresses; one, a continuous or uniform stress, and another kind which you might term a shock stress. Material will withstand comparatively enormous loads if the load be applied gradually and uniformly, but where a shock occurs, the load allowable becomes very much less. With the low first speed the torque is applied so gradually that a blow or shock stress cannot develop. This same condition occurs in connection with the self-locking differential, at least of the type we used. It is possible that this explanation is not exactly lucid, but the fact remains that the parts do not develop weaknesses.

Mr. Perrine:—I know that in designing the aviation trucks Col. Slade was very anxious to use a solid axle without a differential. The Canadians had tried that with considerable success. They were able to get performance out of two-wheel drive very close to that of the existing four-wheel drive at that time due to eliminating the weakness of the differential, but the axle maker shut down on us absolutely. He said that we could not use a 3-ton axle without a differential, that the shafts would go one after the other; that a number of manufacturers had tried it. We would have had to use practically a 5-ton axle for a 3-ton truck to take the torque on the individual axle shafts when one wheel took all the drive.

Mr. Dunham:—The locking up of the differential in a rear-wheel-drive truck does improve the pulling ability. Probably the Canadian trucks to which you referred had very large factors of safety in the torsional parts. There is an objection, however, to locking up a two-wheel-drive differential inasmuch as it makes steering almost impossible in soft going. At a four-wheel-drive test held at Washington in the early part of last year, a Quartermaster B truck was demonstrated with a locked differential. As soon as this vehicle got off the road into the woods, and especially at one place where the ground sloped slightly, the front end could not be controlled as the driving wheels were equipped with chains and had a tendency to move the vehicle ahead in a straight line.

Speaking of steering, there is a general feeling that vehicles equipped with power in all four wheels steer too hard. They do steer hard but unnecessarily so. With this type of vehicle the load distribution is such that the front wheels carry a greater percentage of the load than in the case of rear-wheel-drive types, with the result that the front wheels naturally turn harder than those which carry less load. However, if the steering mechanism is properly lubricated and in reasonably good adjustment, the difference in steering is not great, but acknowledging that there is a theoretical difference, this can be overcome by improvements in the steering-gear proper. The efficiency of the average steering-gear today is only about 30 per cent. This surprising information was obtained in a test by first carefully overhauling the gear, insuring that it was in proper adjustment and well lubricated, and then measuring the power put into it at the hand-wheel and that which was available at the steering-arm. This was checked over several times. A similar test conducted by the Packard laboratory, at about the same time, showed approximately the same result. Undoubtedly a steering-gear with greater gear center-distances and mounted in anti-friction bearings, would permit the four-wheel-drive truck to steer as easily, if not easier than, rear-wheel drives of like capacity today. The same thing could also be done to two-wheel-drive trucks, especially in big capacities, to good advantage.

Mr. Freeman:—I think that the low-gear reduction of the transmission has everything in the world to do with this problem. I had a little experience 2 years ago that I will relate for what it is worth and you can draw your own conclusions. We had a 5-ton truck with two tandem transmissions in it, for the purpose of testing the second transmission. We bought a standard 5-ton truck which had the usual ratios; I think an axle ratio of about 10 to 1 and a transmission low-gear ratio of about 4.8. With the two transmissions one behind the other we got a low-speed reduction of 448 to 1. The actual power transmitted to the wheels was less probably than those figures would indicate, but we never succeeded in damaging the axle or differential or any power transmitting part in the least. I know that you could hold the clutch out, open the throttle, speed the engine up to the limit (the governor would allow about 1200 r.p.m.) snap your foot off the pedal and later the truck would start to move. It was absolutely impossible to transmit any shock load to the axle parts. I think that has a great deal to do with the point under discussion.

Mr. Myers:—The shock proposition is all-important in motor-truck design and has to be looked out for. The minute you remove the chance for heavy shocks, you remove the source of much trouble in motor trucks. The minute you cut down the engine speed in a motor truck and keep it down to an ordinary figure, you get rid of much more trouble also. All you have to do to demonstrate that is to take a truck out on a level for a while until you get used to the noise, etc., and then go over the top of a hill. You can run that truck at double the ordinary speed and you will hardly know you are going.

Mr. Freeman:—We found it advisable and in fact necessary to use fourteen chains on each wheel. When we had fourteen chains on each wheel we could go through places and soft ground that we could not negotiate with the number of chains we started with, six. We increased to eight and finally to fourteen. The reason for that I do not know exactly. When you watch the action of the wheels closely where they have a small number of chains, you will find that the truck sinks just at the time when the chains are not in contact with the ground, while if you have enough chains you do not dig yourself in, provided you have a low enough gear ratio to keep the wheel speed low. You do not have to spin your wheels. The two things seem to go together.

Hot Deformation and the Quality of Steel[1]

By Georges Charpy (*Non-Member*)

IN France many of the official specifications lay it down that to obtain certain parts it is necessary to effect, by forging, a reduction of the initial section of the ingot equivalent to a given figure. These conditions are expressed as the "coefficient of working," which is equivalent to the ratio of the initial section to the final section, or, what amounts to the same thing, the ratio of the final length to the original length. The minimum values assigned to this "coefficient of working" are generally 3 or 4, and sometimes higher.

The question is one that appears to deserve examination afresh, and to be made the object of systematic experiments, the more so as the conclusions which may be arrived at may lead to important modifications in the practice of manufacturing large forgings.

Importance of Local Deformations

It should be noted at the outset that to study the influences of hot working on the properties of steel, it is necessary to take into consideration the local deformation undergone at the very point from which the test piece intended to represent the quality of the metal is to be taken. If the external form of the finished piece be the only guidance afforded in this direction, it should nevertheless be possible to assume that the deformation has been uniform, at least in certain well-determined localities. This remark is sufficient to exclude from systematic experiments the use of pieces obtained by forging under the hammer or the press, at any rate under ordinary conditions. The discontinuous action of such appliances will indeed necessarily produce extremely variable local deformations. The successive compressions which allow of there being effected under the forge or the hammer the shaping of a block of metal impart, to a given point in the ingot, a highly complicated path in the course of which it alternately recedes and approaches the axis, the relative displacement of two neighboring points being even much more irregular. It is only necessary to watch an ingot being forged under the hammer or the press, bearing in mind what has just been said, to realize the great importance of the local deformations; it is more difficult to follow them exactly. An approximate value may be assigned to the variations by making datum marks on the ingot.

Table 1—Tensile Tests of Differently Rolled Blooms

Coefficient of Working	Longitudinal Tests: Tensile Strength	Longitudinal Tests: Elongation	Longitudinal Tests: Reduction in Area	Transverse Tests: Tensile Strength	Transverse Tests: Elongation	Transverse Tests: Reduction in Area
1.7	91.2	20	111	90.9	18	76
3.2	91.6	20	140	90.5	16	57
6.1	90.5	22	170	90.6	12	31

The rolling of an ingot into bars introduces no dissymmetry along its axis; test pieces taken from the same bar at equal distances from the axis may be regarded as having undergone exactly the same deformation. It would, perhaps, be straining matters to extend this conclusion to test pieces taken at different points in the same transverse section, but there is, on the other hand, a dominant reason to forego comparison of such test pieces owing to the variations in composition and in structure which are inevitable in the transverse sections of any ingot. This can be seen in comparing two bars of different sections, by collating the results furnished by test pieces taken from regions corresponding with the same fractions of the total radium and therefore with the same region in the mother ingot.

I will now describe certain experiments which were carried out, and, bearing in mind what has already been said, will endeavor to determine the influence of hot-working on the properties of steel.

First Experiment—Gun Steel

Three identical ingots of a 355-mm. square section with rounded corners were cast simultaneously. The metal employed was a gun steel, made in an acid furnace from materials of the quality which will best serve to give satisfactory results in tests from bars cut perpendicular to the direction of drawing down. These three ingots, regarded as identical, were rolled after having been heated under exactly the same conditions, and reduced to the dimensions of 225 by 225 mm. for the first, 165 by 165 mm. for the second, and 125 by 125 mm. for the third. The coefficients of working were thus 1.7, 3.2 and 6.1. From each of the resulting blooms test pieces were taken for tensile, shock bend and notch tests with both longitudinal and cross notches. These test bars were all cut from points taken from the same regions of the ingot both in the longitudinal and transverse directions and were situated at one-third of the distance between the surface and the axis so as to avoid the influence of segregation and of axial porosities; their axes were thus identical from all points of view, except from that of the "coefficient of working."

Table 2—Impact Tests on Notched Bars

Coefficient of Working	Longitudinal Tests 1	Longitudinal Tests 2	Transverse Tests 1	Transverse Tests 2
1.7	6.5	7.1	5.3	5 8
3.2	7.9	8.3	3.9	4.1
6.1	9.9	10.1	3.5	3.5

The test bars were quenched and annealed under exactly similar conditions, quenched from 850 and annealed at 600 deg. cent., and then subjected to tests. The following results were obtained:

The tensile strength of each is practically the same. The elongations increase slightly in the longitudinal samples under hot working and decrease notably in the transverse test bars, and the same thing, only much more markedly, occurs in regard to the reductions in area. It is, however, the variation in reduction of area which alone influences the total elongation, the curves of tensile strength being practically identical and superimposable, up to the breaking point. The fractures vary naturally with the reductions in area. They are normal even in the transverse bars in the case of the bloom which has undergone little deformation and take an

[1]From a paper, substantially in full, presented at the 1918 Fall Meeting of the Iron and Steel Institute, London. The author is the famous French metallurgist and the originator of the Charpy impact testing machine.

oblique form in the transverse bars which have been strongly worked.

The impact bend tests were made on two bars 9 by 24 by 75 mm., clamped at one end and subjected to the impact of a 10-kg. tup falling from a height of 1 m. None of the longitudinal bars could be broken by impact. The transverse bars broke respectively after twenty-nine, twenty-seven and twenty-three blows.

The bars, measuring 10 by 10 by 53.5 mm. were notched half-way through and tested under the drop-test machine. Two bars were tested from each bloom, the notches being given the two rectangular positions possible in the circumstances. The figures in Table 2 show the work absorbed by rupture, expressed in kilogrammetres and calculated per square centimeter of the section at rupture.

The variations here are much more marked and most sharply defined. Hot working increases the impact resistance longitudinally and diminishes it greatly in the transverse direction, the more so the greater the amount of deformation. Within the limits of the experiment the average differs but slightly.

Second Experiment on Same Steel

Instead of taking several different ingots two fragments from the same ingot, the same metal as in the preceding experiment, subjected to different amounts of working, were compared. In the first heat the section was reduced from 355 by 355 mm. to 225 by 225 mm., and, secondly, a piece of the bloom thus obtained was submitted to a second heat and the section reduced to 125 by 125 mm. The piece from the first bloom, which had not been rerolled, was replaced in the reheating furnace at the same time as the second piece, so that it should undergo the same heat treatment. The results agreed completely with those of the preceding experiment.

The two longitudinal bars did not break. Neither did the transverse test bar, which had been but little worked. The transverse test bar which had undergone most working broke at the forty-second blow from the tup. Results are given in Table 4.

Third Experiment—Hard Basic Steel

The preceding experiments were carried out on metal chosen in such a manner as to eliminate, as far as possible, the differences between the test bars taken, both in regard to the amount of work they had undergone and in regard to its direction. It appeared necessary to try the second experiment over again on a metal of the

Table 3—Tensile Tests of Gun Steel

Coefficient of Working	Longitudinal Tests: Tensile Strength	Longitudinal Tests: Elongation	Longitudinal Tests: Reduction in Area	Transverse Tests: Tensile Strength	Transverse Tests: Elongation	Transverse Tests: Reduction in Area
1.7	91.6	18	110	92.2	18	87
6.1	91.3	22	165	92.5	14	54

same grade and of current quality, and semi-hard basic steel, as used in the manufacture of shells, was used.

An ingot 355 by 355 mm. was taken and treated exactly as described above, except that in the heat treatment of the bars annealing was carried out at a higher temperature, 650 deg. cent., than in the preceding case, so as to diminish the increase in the tensile strength due to quenching and to get the metal into the condition of minimum brittleness. The results obtained are given in Table 5.

The two longitudinal bars broke after seventeen and forty blows from the tup respectively. The two transverse bars broke after the eighth blow.

The notched bar tests are summarized in Table 6.

The experiments described confirm and emphasize a series of results of a qualitative nature obtained earlier.

Results obtained with bars from the large ingot, which weighed 10,000 kg. and had a cross-section of 61 square decimeters, are distinctly inferior to those obtained with bars from the small ingot, which weighed 800 kg. and had a cross-section of 8.6 square decimeters. It would therefore appear to be a certainty that, in regard to pieces tested transversely, a mistake is made every time

Table 4—Impact Tests on Notched Bars of Gun Steel

Coefficient of Working	Longitudinal Tests: 1	Longitudinal Tests: 2	Transverse Tests: 1	Transverse Tests: 2
1.7	7.5	7.5	5.3	6.0
6.1	9.3	9.5	3.5	3.2

an attempt is made to improve the quality by increasing the amount by which the metal is drawn down.

Results relative to the influence of hot working on the properties of steel appear to be pretty easily ascertainable, taking into account the new data as to the heterogeneity of steels which the new cupric reagents recently employed by Drs. Rosenhain and Stead and Mr. Le Chatelier enable us to obtain. If specimens obtained by this process are examined, they show that the dendrites formed during the solidification of the steel undergo deformation during rolling, but do not in any way tend

Table 5—Tensile Tests of Hard Basic Steel

Coefficient of Working	Longitudinal Tests: Tensile Strength	Longitudinal Tests: Elongation	Longitudinal Tests: Reduction in Area	Transverse Tests: Tensile Strength	Transverse Tests: Elongation	Transverse Tests: Reduction in Area
1.7	70.1	18	33	70.7	11	27
6.1	72.7	23	60.5	68.4	4	8

to disappear. Subsequent heat treatments do not modify this structure. There is thus found in juxtaposition in steel two series of elements corresponding with two different compositions and the mechanical properties of which differ.

Rolled steels will therefore always present a structure

Table 6—Notched Bar Tests on Hard Basic Steel

Coefficient of Working	Longitudinal Tests	Transverse Tests
1.7	3.50	2.00
6.1	9.10	1.50

composed by the juxtaposition of elements practically rectilinear and parallel with the direction of rolling and the transverse dimensions of which will be the more reduced, according as, other things equal, the coefficient of working has been greater.

Conclusions

From the collection of facts and considerations contained in this paper it may be concluded that the amount of the deformation undergone at a high temperature by a block of steel affects the properties of the metal according to a complex law which involves the initial stage of the ingot and all the subsequent deformations and the chief characteristic of which is to create strongly marked heterogeneity. There is found to be a variation in the properties not only of degree but of nature as well, according as the direction of the test bars employed varies in relation to the piece whence they are derived. The total effect is far from being in the nature of a general improvement, as would appear to be looked for whenever, in specifications, a minimum amount of working is prescribed. It would appear, on the contrary, that the result is more injurious than useful and that consequently the specification of a maximum deformation would be more logical.

It is impossible to fix a general rule. For pieces working under transverse stresses, such as guns, drawing

down lengthwise has undoubtedly an injurious effect, at any rate in mechanical tests required in inspection, and it would be better to reduce it as little as possible.

For steel parts of more complex shape the problem differs in each specific case, and it would appear that the only guidance is by studying the conditions beforehand. The designer, who knows how he wants the part he has designed worked, should construe his ideas into deciding the localities from which test pieces should be taken corresponding with predetermined conditions. These test pieces should be taken in different directions if these be the conditions under which the material will be employed, and the metallurgist, to meet with these fixed conditions, should in each case select the type of ingot to be employed and the nature of the deformations to which it is to be subjected.

Much Work Has Bad Effect

Dr. J. E. Stead in opening the discussion said that for generations engineers and others had always assumed that the more work put upon steel the better it was. Georges Charpy now says that this is not so in every case; that in cross-sections the more work put on the steel the worse it became. Dr. Stead's own work, extending over a great many years, had practically confirmed the author's results. Years ago, when he had many rails to test and examine, he made a point of cutting sections from the heads, and then placing them over a V-block and striking them on one side. Except in the case of very pure metal they all broke off suddenly, almost like cast iron, without deflecting more than 5 or 6 deg. He found, however, that this peculiarity depended very largely upon the amount of non-metallic inclusions present.

Judging from the remarks of the author and also from observations generally in his own work, it might be concluded, he said, that the purest steel castings when initially sound and perfectly made and heat treated were equal physically in every direction. In proportion as the non-metallic inclusions increased, bend tests indicated proportional weakness in all directions. In cast material, after extensions by hot rolling, the less the amount of non-metallic inclusions the better the steel in the cross direction; the higher the proportion of the inclusions, the worse would be the bending properties in that direction.

The worst case of weakness in the cross direction he found in wrought irons. The purest and best Yorkshire wrought irons when cut through in cross-section and struck with a hammer broke off, bending only about 5 deg. before suddenly snapping. The higher the sulphides and inclusions, the more closely the properties of steel approached those of wrought iron, and the cross fractures resembled each other in appearance. The quality was not at all deteriorated in the longitudinal direction, but in proportion as the sulphide of manganese and non-metallic inclusions were increased, the good qualities were reduced in the cross direction. Commercial billets and steel bars containing from 0.07 to about 0.30 per cent of carbon and 0.07 of sulphur, in 1/4-in. longitudinal sections, all bent to 180 deg., but the cross-sections broke on bending from nothing at all to about 90 deg.

In the very purest material obtainable, he continued, in which there were practically no non-metallic inclusions, it did not matter whether the bars were 2-in. billets or 1-in. squares, the cross and longitudinal sections bent equally well.

Forging and Rolling Contrasted

Incidentally, Dr. Stead said, he would like to refer to the difference in the effect of forging and rolling. When an ingot was rolled out, the whole section was just reduced in size. If it was a 2-ft. ingot, on rolling down to a 2-in. billet all the sulphide blowhole segregations were in exactly the same relative position as they were in the ingot. When square ingots were forged under the hammer, they were struck first on one side and then at right angles to that side. The steel flowed in four directions, that which flowed sideways causing the steel to bulge outward. On turning the forging at right angles the steel of the "side bulges" was driven toward the central axis and other bulges formed on the sides which had been at first compressed, and in turn these were hammered flat and this continued till a square billet was produced. This treatment caused the annular arrangement of the blowhole segregation in the ingot to be disturbed and to appear in the form of a four-limbed star, in the cross-section of the billet, with its limbs pointing to the four corners. He suggested that M. Charpy's paper should have the serious consideration of the engineering standards committee.

Cosmo Johns believed that it was not the amount of the work which was done that was the cause of the difficulties which were sometimes experienced; it was rather the character of the work that gave rise to it. In the extension of a large ingot to make a hollow forging, it was usually possible to break up the original crystals but not always possible to succeed in preventing the persistence of the boundaries. Large crystals persisted in a particular direction. It was impossible to do too much work on steel provided the temperature was right, but it was very easy to overwork the steel in the wrong direction. Rolling was perhaps the most convenient but the least efficient way of breaking up the structure; forging and hammering for the smaller pieces and pressing for the large ones, provided the energy available was proportional to the thing being forged, came next. The best of all was some system which could only be applied to small products, where work was done upon the steel in every direction. That was most calculated to give a good structure.

Effect of Different Sized Hammers

Dr. J. S. Unger said he was reminded of some specifications that the United States steel makers had to meet at the present time. He had in mind a certain specification in which it was definitely stated that the reduction from the ingot to the finished forging must at least be a ratio of 4 to 1. He was also reminded of a practical example that he experimented with about 3 years ago in relation to some driving axles for locomotives. One of the railroad companies insisted on having a certain reduction from the ingot to the finished axle. They thought the work that was done by the manufacturer was not sufficient to put it into the most satisfactory physical condition. To demonstrate this they took a bloom about 15 in. square, discarded the top half to eliminate any segregated portion and cut the remainder into three pieces, sending one to each of three firms, who forged them into rounds, at one firm under a 7000-lb. hammer, at another firm under a 15,000-lb. hammer and at the third firm under a 2000-ton hydraulic press.

A study was made of the effects of the hammers and the 2000-ton press and of the effects of different reductions of 50 per cent, 40 per cent and 30 per cent. After forging, the pieces were allowed to cool normally in the air, and longitudinal test pieces were taken out of various parts. Much to his surprise he found practically no difference in the physical qualities of the tensile specimens. The work done under the 2000-ton hydraulic press

gave a trifle the best results. He felt that was due to the slower action of the forging press, and that the difference in the results was more particularly due to the finishing temperature than to any effect produced by the working.

Dr. Unger said he had grave doubts as to whether, in a great many cases, the manufacturer was not asked to do more forging than was really necessary. On another occasion he made further experiments, in which he found that if he was able to forge a piece with about 25 per cent reduction, he did as well as if he gave it 50 per cent reduction.

Value of the Charpy Notch Tests

Sir Robert Hadfield, referring to the impact tests given in the paper, said he presumed those tests were made on the ordinary Charpy test bars. If so it was important to know whether the tests were made on the large or the small pattern, as Charpy had several types of test bars. They were greatly indebted to the author for the system he had devised of notched-bar tests. He would never forget walking through the great Essen works and research laboratories a year before the war, and noticing that much of the so-called wonderful Krupp advance had been founded on the work of M. Charpy and his notched-bar test experiments. It showed that the metallurgical world was indebted to France rather than Germany in that respect.

Mr. Hadfield said he was very glad to find that the author confirmed the statement which he had made before the last meeting of the Institute, namely, that to get the highest possible quality it was not necessary to employ extraordinarily large ingots. There was no doubt whatever that by proper heat treatment and casting and the obtaining of sound smaller ingots or smaller cast billets, just the same results—in fact, he thought on the whole better results—could be obtained than by taking a very large ingot and forging down to a small-size section. In the latter case, especially with harder material, the steel ran considerable risk of being injured in this, what might be termed, over-forging.

Dr. W. H. Hatfield, after saying that if an engineer were reading the paper he might legitimately deduce from it that work upon material was a disadvantage, and that it was far better to take the cast material, remarked that the question was by no means simple, because it was necessary, in the first place, to obtain perfectly sound steel. To obtain a mass of perfectly sound steel it was necessary to have an ingot shaped so that it was wide at the top and narrow at the bottom, with a good refractory head.

Sulphur in Steel

At a recent meeting of the Institute a long discussion occurred on the question of sulphur in steel, and several very distinguished members of the body actively encouraged the use of steels with high sulphur contents. Sheffield people who had to produce large masses of steel looked askance at the suggestion. It was clear from the paper that if the sulphur content was increased there would be much more manganese sulphide present, with the result that the effect to which the author referred would be strongly emphasized. The Sheffield manufacturers, therefore, always insisted on a very low sulphur content in their special steels. Dr. Hatfield said he mentioned that particularly because several gentlemen to whom he had recently spoken had assumed it was quite safe to increase the sulphur content of steel substantially.

Dr. Walter Rosenhain thought the suggestion that the paper might be read to indicate that steel which had not had any work done on it was the best was not a logical one if the paper was read carefully. Cosmo-Johns, however, had suggested that the best results would be obtained if it was worked equally in all directions. If this were done, the net result would be no change of shape or volume at all, and that, of course, would be impracticable. One found that it was useful to employ changes of shape in as many directions as possible. For instance, in the production of any form of flat material, such as sheets or plates, if it was possible to roll in two directions and not in one there was a very much greater certainty of securing good tests in both directions of the sheet. In steel practice, cross-rolling was almost universal, but there were other materials in which cross-rolling was the exception rather than the rule, and it was found at once in those cases that, unless cross-rolling was done, a good transverse test was not obtained. That was the case, with one proviso. If the ingot was carefully cast, and if the materials were sufficiently pure, then cross-rolling was not necessary.

The lesson to be drawn appeared to be that what they must look for was not only a sound ingot but an ingot proportioned as nearly as possible to the size and the shape of the object which was to be made, so that the reduction of dimensions should be not only uniform in direction but should be as nearly equally distributed as possible. If a long, narrow object had to be made, that requirement could not be met, and it was then essential to look after the other factors to which Dr. Hatfield had drawn attention.—*The Iron Age.*

ANNUAL MEETING OF THE SOCIETY

THE program for the 1920 Annual Meeting of the Society has been prepared by the Meetings Committee.

The meeting will be held in the Engineering Societies Building, 29 West Thirty-ninth Street, New York City, on Jan. 6 to 8, 1920. It will commence at 10 o'clock on the morning of Tuesday, Jan. 6, with a meeting of the Standards Committee at which reports of the work accomplished since the Semi-Annual Meeting at Ottawa Beach will be presented by various Standards Committee Divisions. This will be followed by a Council Meeting at which the reports as adopted by the Committee will be considered for presentation to the general meeting of the Society.

The first session of the meeting of the Society proper will convene at 10 a. m. on Wednesday morning and, as has been the custom, will be a business session at which President Manly will make an address and matters of importance will be considered, including the report of the Standards Committee. It is contemplated that some papers on general subjects will be presented at this session. The Wednesday afternoon session will be a general professional session, papers dealing with aluminum pistons, automotive steam systems, body design and spring suspension being scheduled.

The session of Thursday morning will be known as the Fuel Efficiency Session and papers dealing with ways and means for the more efficient use of fuel will be presented and discussed. The concluding session on Thursday afternoon has been designated as the Research Session. It is expected that in addition to the report of the Research Committee of the Society a number of papers concerned with research work and the apparatus used in connection therewith will be considered.

The concluding feature of the meeting will be the annual dinner on Thursday evening at the Hotel Astor. It is announced that John Kendrick Bangs will act as toastmaster.

On Wednesday evening a Carnival will be held at the Hotel Astor. This will be the social occasion of the meeting for the members and their families and guests, including a reception and a dance as last year, and other very attractive features on which the committee is making a special effort. Full details will be furnished the members as promptly as possible.

The meeting will be held during the week of the next automobile show in New York, which will undoubtedly be one of decidedly unusual interest to the members. A motor-truck show will be held in New York during the same week at the Eighth Regiment Armory where ample space will be provided for what is expected to be the largest motor-truck show ever held.

HIGHWAY LEGISLATION

THE object of the Townsend National Highways Bill, recently introduced in the Senate, is to establish and maintain a system of highways according to a national plan connecting the different states of the Union and affording an example of proper highway construction that will be beneficial to the states. This work would be directed by a federal commission making reports annually to Congress as to what is being accomplished. Both the construction of national highways and the operation of the Federal Aid to Good Roads Act would come under the direction of this commission.

Senator Townsend has been asked what effect the proposed legislation would have on the Federal State Aid Law, and has stated that there would be no conflict in the execution of the laws, both running along in their own channels except that the Federal Aid Law would be transferred from the jurisdiction of the Department of Agriculture to that of the Federal Highway Commission. It is Mr. Townsend's intention to have the commission appointed under the proposed law composed of men representing different sections of the country who have had ample experience in road construction work.

One of the reasons for the recent setback in road construction work under the Federal Aid Law is the decision of the Judge Advocate General and the Secretary of War not to turn over more motor-truck equipment to the states for construction work. The Military Affairs Committee has drafted a bill giving authority to turn over this material promptly.

Some states, especially in the South, have been greatly hindered by lack of freight cars to transport material.

Problems of Motor-Truck Operation

By F. W. DAVIS[1] (*Member*)

BUFFALO SECTION PAPER *Illustrated with* CHARTS

KEY TO FORMULAS AND SYMBOLS

The symbols and formulas given below relate to all of the charts reproduced as well as to the text of the paper and are grouped in this way for ready reference by the reader:

A = Actual Cost of Gasoline per Mile
B = Weekly Bonus Based on Gasoline Consumption and Time
B_1 = Bonus Based on Tire Mileage
B_2 = Bonus Based on Gasoline Mileage per Week
B_3 = Bonus Based on Repair and Maintenance Costs
B_4 = Bonus Based on Time per Week
B_j = Weekly Bonus Depending on Coefficient of Maintenance
C = Standard Cost of Gasoline per Mile
D = Distance per Round Trip in Miles
E = Approximate Efficiency of Operation
E_2 = Accurate Efficiency of Operation
F = Number of Days Operated per Week
G = Guaranteed Tire Mileage
H = Number of Hours per Day Truck Is in Service
J = Base Rate Depending on Coefficient of Maintenance
L = Sum of Actual Loading and Unloading Times per Trip in Minutes
L_1 = Sum of Standard Loading and Unloading Times per Trip in Minutes
M = Number of Miles Covered by Truck per Day
N = Number of Trips Made per Day
Q = Mileage Actually Obtained from Each Individual Tire
R = Running Speed in Miles per Hour (Assumed as 10.5)
T = Time per Round Trip in Minutes
W = Driver's Wages per Week in Dollars

$$D = \frac{M}{N} \qquad T = \frac{60H}{N}$$

$$T = \frac{60DH}{M} = L + 5.7\,D$$

$$E = \frac{860}{T + 11.4 - 5.7\,D}$$

$$E_2 = \frac{860}{L + \dfrac{2\,(T - L)}{D}}$$

BONUS SCALE BASED ON EFFICIENCY FORMULA

$$\frac{L_1 + 11.4}{T + 11.4 - 5.7\,D}$$

$$B_1 = \frac{Q - G}{1000} \text{ (No Definite Time)}$$

$$B_2 = \left(\frac{C - A}{2}\right)FM \text{ (Weekly)}$$

B_3 Is No Definite Figure but Influences B_4

$$B_4 = \frac{W}{L_1}(L_1 - T + 5.7\,D) \text{ (Weekly with Limiting Bonus} = W)$$

$$B = B_2 + B_4 \text{ (Weekly)}$$

$$= \left[\left(\frac{C - A}{2}\right)FM\right] + \left[\frac{W}{L_1}(L_1 - T + 5.7\,D)\right]$$

$$B_j = \frac{J}{L_1}(L_1 - T + 5.7\,D)$$

Total Weekly Wage Including Bonus =

$$B + W = \left[\left(\frac{C - A}{2}\right)FM\right] + \left[\frac{W}{L_1}\left(L_1 - \frac{60H}{N} + 5.7\,\frac{M}{N}\right)\right] + W$$

IN the past 10 years the motor truck has received considerable public attention and particularly so in the war operations over the past 4 years. It is one problem to build a motor truck and a very different one to operate it. From my experience covering the manufacture, sale and operation of motor trucks, the conclusion is reached that if the average truck were designed and made with the same intelligence and supervision that the average truck receives in service, the thing would not go together, and if it did, it would not run. This is said with all due respect to truck operators and is merely put forth as an opinion, as any attempt to establish this one way or the other would hardly be called constructive criticism. The establishment of the Highways Transport Committee, and the meetings held by the Truck Owners' Conference are steps in the right direction, and out of these efforts much valuable information should be obtained in the way of improving motor truck operation.

It is said that every man, woman and child with $200 in hand is a potential automobile owner. Against this it is stated that the market for trucks is not nearly so large but is limited by traffic in the cities and roads in the country. This is true to a certain extent. However, through intelligent operation of motor trucks it is pos-

[1]Truck engineer, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

sible to handle at least twice the amount of work with the present number of trucks without in any way affecting the traffic conditions. This increased work output will also show a corresponding reduction in cost. The problem of investigating this subject is not so much where to start, as in knowing when to stop.

Before going into the analysis of one or two phases of this subject I will establish a few fundamentals so as to have a common basis to work from. I will divide the cost of operation under two main headings, fixed charges and operating expenses per mile. Under the amount of work done we are concerned with the number of hours per day, the time per round trip and the load per trip.

In looking over any typical cost figures, the item of driver expense is by far the most important, as it represents from one-fifth to one-fourth the total cost of operation, and furthermore the driver controls more or less completely the entire operating expense, representing about two-thirds the total cost of operation. In addition to all this the driver is the one individual who largely controls the amount of work done by the truck, therefore, he becomes a very important personage, and to obtain results he must be chosen carefully, taught correctly and given the proper inducement to produce results. The matter of the selection and teaching of the driver is self-evident and due to this fact is not again considered in this paper. Consequently on the assumption that the driver is selected and has been carefully trained the problem becomes that of securing better results. The driver is working for you for the money there is in it; therefore it does not take much logic to see that the pay envelope offers the connecting link between reduced cost of operation, more work from the truck and a satisfied man.

Bonus Systems

A bonus system furnishes the means of accomplishing this.

There are several bonus systems in operation today, and in spite of the criticism that some of the systems are open to, the results obtained are in almost all cases satisfactory, and this alone appears to argue that through the establishment of a bonus plan the results obtained entirely justify the system.

I will give a brief statement of several typical plans together with brief comments on the particular merits of each. One plan is to grant a $2 per week increase each 6 months if the operating cost is kept within certain definite limits. This is simple in application but does not offer an inducement bearing any proportion to the results produced. A second method is to pay the driver a certain percentage of the saving over the average cost of gasoline, oil, tires and repairs. This is good but somewhat vague and does not cover the whole situation. The third plan is the payment of $1 for every 1000 miles a driver uses tires over the guaranteed mileage. This is very good so far as tire mileage is concerned, as solid tires cost from $12 to $22 per 1000 miles. In the fourth a bonus is paid to the loaders based on the so-called Emerson Curve. That is, the bonus starts at 80 per cent of the so-called maximum, and the loaders get an equivalent percentage of wages for everything over 80 per cent. The problem here is to set standards, but in the place where it is used it is claimed to be effective and easy to carry out. This system is good so far as the loaders are concerned but is not comprehensive enough. Still another plan is to pay a bonus on the ton-mile basis. An average cost per ton-mile is selected, and the driver obtains a bonus of half the saving which he is able to effect in cost per ton-mile below the average figure times the ton-miles covered.

The subject of ton-mile cost for motor trucks is a very complicated one. It will suffice at the present time to point out that the cost per ton-mile is equal to the cost per day, divided by average load carried, times mileage per day. The total cost per day is only partially under the driver's control. The average load carried is dependent on the capacity of the truck and the available material and consequently it is entirely independent of the driver. The mileage per day is almost entirely dependent on the distance per round trip. Consequently the driver can only vary it so as to increase the distance per round-trip, or to run what we can designate as excess mileage. Therefore we can say that the cost per ton-mile is made up of a factor partially under the driver's control, divided by the product of two factors, one of which is not under his control and the other under it only to the extent that he can only vary it so as to produce excess mileage. To utilize a bonus system founded on the ton-mile basis is not only complicated but entirely at variance with the results sought for. A true bonus system should refer only to factors under the control of the driver.

Under the heading of cost factors the driver more or less controls the tire, gasoline and oil costs and has a very decided hold on repairs, maintenance and depreciation. He exerts very definite control over the loading and unloading time and the operating speed. The problem then becomes one of devising a bonus plan for taking into account the factors under his influence.

The basis of $1 per 1000 miles over the guaranteed tire mileage is a convenient and satisfactory figure for a tire bonus. In the matter of gasoline consumption, the driver is to receive one-half the amount saved over the standard cost. No bonus is to be offered on the oil cost, as this is the smallest item of expense, and any attempt to reduce this still further is a direct invitation to mechanical troubles of a very serious nature. A schedule for a bonus covering repairs, maintenance and depreciation will be considered further on. The remaining items to consider are loading and unloading time and operating speed.

Developing a Bonus System

In the records available on truck operation it is almost always possible to find the number of hours per day, the number of trips per day and the number of miles per day. On the assumption of a running speed of 75 per cent of the maximum governed speed, which in the case of a Pierce-Arrow truck governed to 14 m.p.h. works out at 10.5 m.p.h. running speed, we are able to express the loading and unloading time in the following simple relation:

$$T = L + 5.7\,D$$

The time T per round-trip does not offer a basis for working out a bonus system as this varies with the length of the haul. What we are seeking is a basis entirely independent of the length of haul.

Some time ago I worked on this subject in endeavoring to obtain an efficiency basis for truck operation and stated the case in the following manner:

> If two trucks working in different length hauls load and unload in the same time and run at the same average speed they are operating at equal efficiency.

If we can somehow juggle this into a simple formula and determine a base rate and limiting amount of bonus, then our problem of determining a bonus for loading and

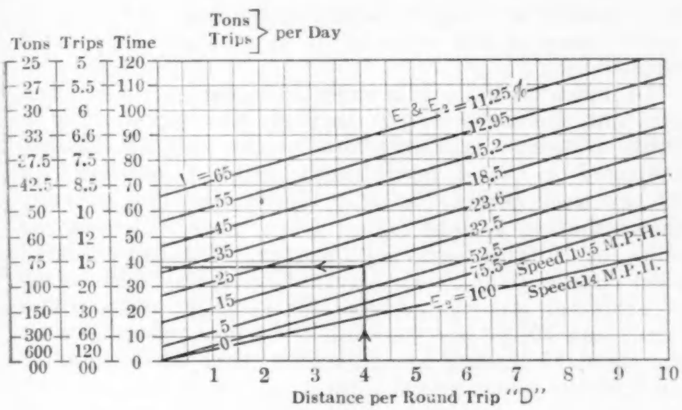


FIG. 1

unloading and running speed would seem to be solved.

Referring to Fig. 1, a graphical representation of the above statement is presented by the series of parallel lines reading from $L = 0$ to $L = 65$.

The efficiency formulas shown by E and E_2 are based on a standard length haul of 2 miles per round trip. In this case 100 per cent is reached only when the running speed is 14 m.p.h. and the value of $L = 0$. To obtain a standard time from which to consider a bonus we choose a value of L, and any point on the line shown on this chart corresponding to the assumed L becomes the standard time for any length of haul.

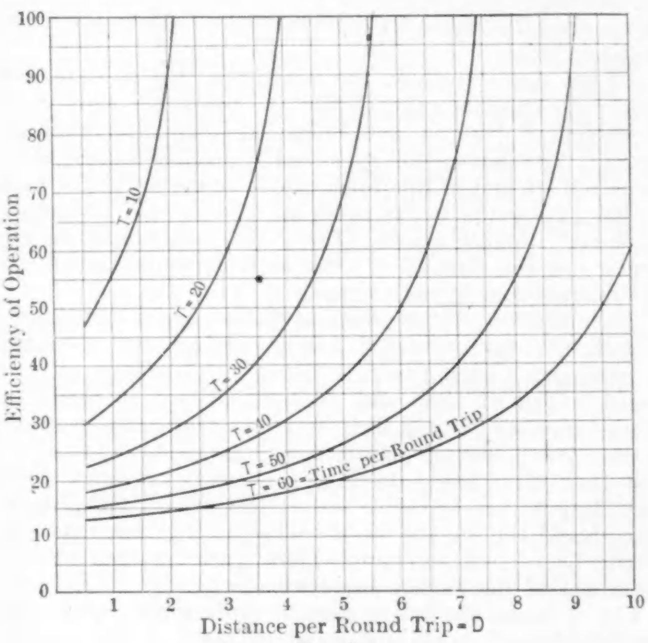


FIG. 2

ard time for any length of haul. This is entirely independent of the length of haul, and is the basis we are seeking for to establish a bonus system.

Fig. 2 shows the so-called truck efficiency in graphical form. If we take this formula and substitute the running speed of 10.5 in place of 14 m.p.h., and add to this a base rate for loading and unloading time of L_1, we then have a relative efficiency or bonus scale. If we take the base rate equal to the weekly wage received and the limiting amount of bonus equal to the weekly wage, we are in a position to prove this out and analyze the results.

Typical Application of the Bonus Scale

Fig. 3 represents a bonus scale worked out as outlined above with a typical example shown. The characteristic of these curves is similar to the efficiency chart. The dotted lines shown below the base line obtain no bonus. The example indicated of $D = 6$, $T = 40$, works out to a relative efficiency of 1.74. With a base rate of \$20 per week the driver then receives \$20 $\times$ 1.74 or \$34.80 per week. Under these conditions the base loading time of L_1 is assumed at 20 min., but with a round-trip time of 40 min. for a 6-mile trip and 10.5 m.p.h. operating speed, the loading and unloading time is actually 5.8 min. instead of the standard 20 min.

A study of the curves on this chart shows the relative

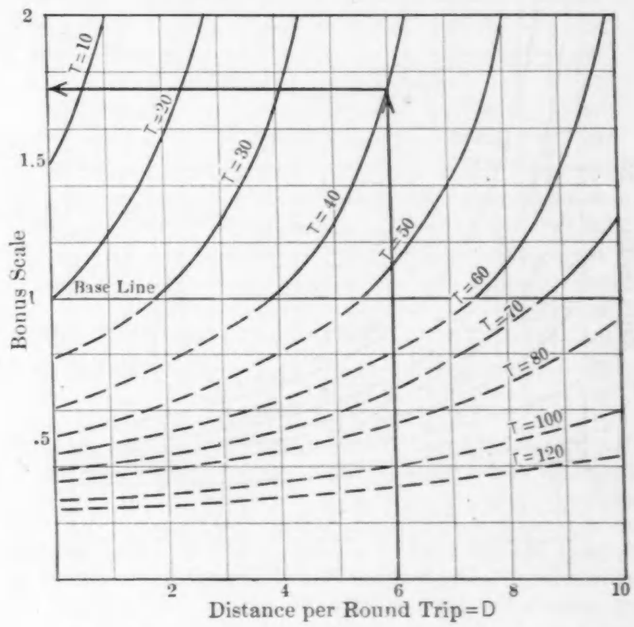


FIG. 3

efficiency equal to 2 when the loading and unloading time equals 5 min., and as agreed above this should be the limiting bonus. We can modify the above formula somewhat and express it as

$$\left(\frac{L_1 - L}{L_1} \times W\right) = \text{Bonus}$$

When $L = L_1$, bonus $= O$ or weekly wage $= W$
When $L = O$, bonus $= W$ or total weekly wage + bonus $= 2\ W$.

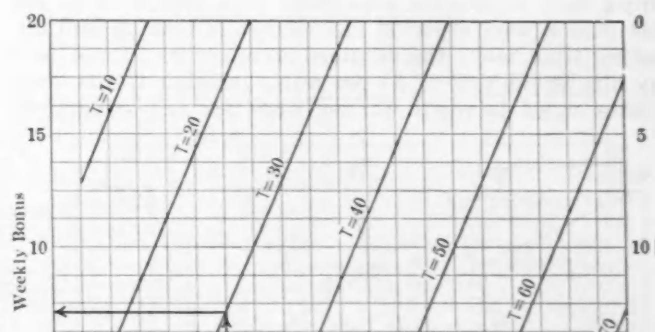


FIG. 4

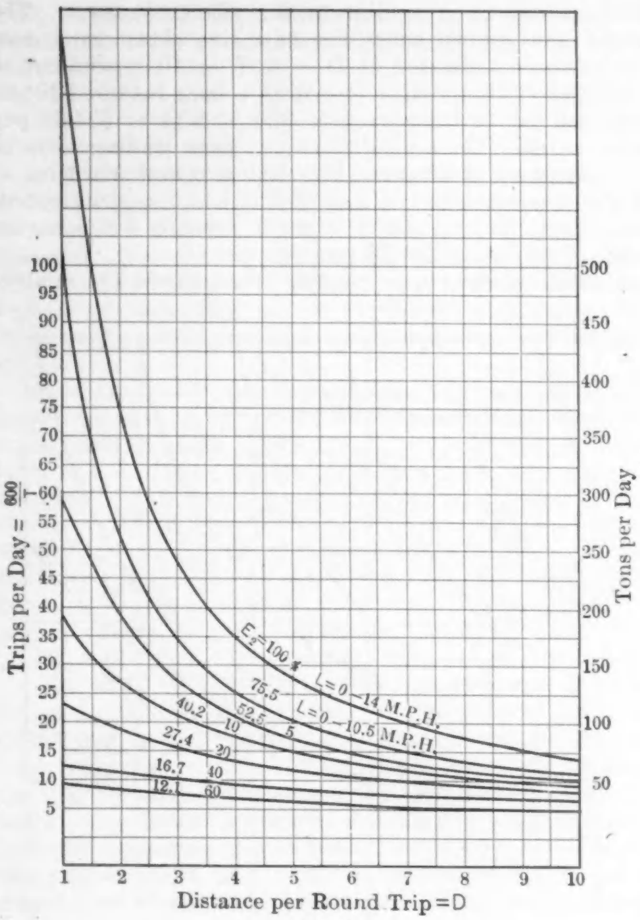


FIG. 5

Expressing the above bonus formula in terms of T and D in place of L from the expression $T = L + 5.7D$

$$\text{Bonus} = \frac{W}{L_1}\left(L_1 - T + 5.7\,D\right)$$

Therefore while the bonus scale appears to consider only loading and unloading time it also gives credit for running speed, as the factor L is expressed in terms of an assumed 10.5 m.p.h.

Fig. 4 shows this modified bonus formula to be much easier to handle than the previous one and that the variation throughout the selected range is very small. A simple way to explain this chart to a driver is to say that over a week's period any saving in loading and unloading time below the assumed standard of 20 min. will pay him at the rate of $1 per min.; in other words, each minute saved is worth $1 per week for the driver. If this amount is thought excessive, the base rate can be made lower or the value of L_1 can be chosen to suit conditions.

To indicate what can be expected in the way of reduced cost and increased output through the operation of a bonus system as outlined above, we can take the example indicated on Fig. 4, in which the driver is entitled to a $7 per week bonus. A little figuring on this example shows that in a 10-hr. day a 5-ton truck will cover 60 miles, or 20 trips, carrying 100 tons. With an assumed fixed charge of $6.50 per day and operating expense of 20 cents per mile the cost per ton is $0.185 without the bonus and $0.196 per ton with the bonus, whereas with the standard loading and unloading time of 20 min. in place of the above actual loading and unloading time of 12.9 min. the cost works out at $0.20 per ton and the truck carries but 80 tons per day. The essential fact in this case is not that the rate with the bonus is slightly under the standard rate of $0.20 per ton, but that eight trucks, working according to the example, will do the work of ten trucks at the standard L_1.

Anyone doubting the value of reducing loading and unloading time and keeping up running speed should study Fig. 5. This chart offers a very complete answer to the often-heard statement that trucks do not pay in short hauls. It is true that the loading and unloading time has a vastly greater effect in short hauls than in long ones. However, when quick loading and unloading are accomplished the results with a motor truck in short hauls are astonishing in the way of tonnage handled and cost per ton.

I have now explained the bonus for tire mileage, the bonus for gasoline mileage and the bonus for work done in terms of loading and unloading time and running speed. The bonus for gasoline is readily shown as a weekly item, and in this form can be added to the formula developed for the bonus covering loading and unloading time and running speed. The tire bonus cannot be expressed in the element of time as it depends entirely on the mileage run by each tire.

The question of the effect of maintenance and depreciation must be considered, but it hardly seems advisable to cite any figure for this because it extends over a great length of time and depends largely on make of truck, previous history, etc. It seems preferable to speak of the "coefficient of maintenance" as grade A, B or C, and then alter the base rate for bonus on work done according to the classification of the driver. This base rate should replace the weekly wage as the base rate and should be subject to change from week to week on the judgment of the garage superintendent.

Fig. 6 shows the driver's bonus scale worked out with the "coefficient of maintenance" in place of the weekly wage as the base rate.

The various symbols and formulas are given at the beginning of the paper. It is not claimed that the latter are correct for all conditions. This analysis of drivers' bonuses is offered in the hope that it will stimulate thought on a subject that is felt to be of very great importance in obtaining better results.

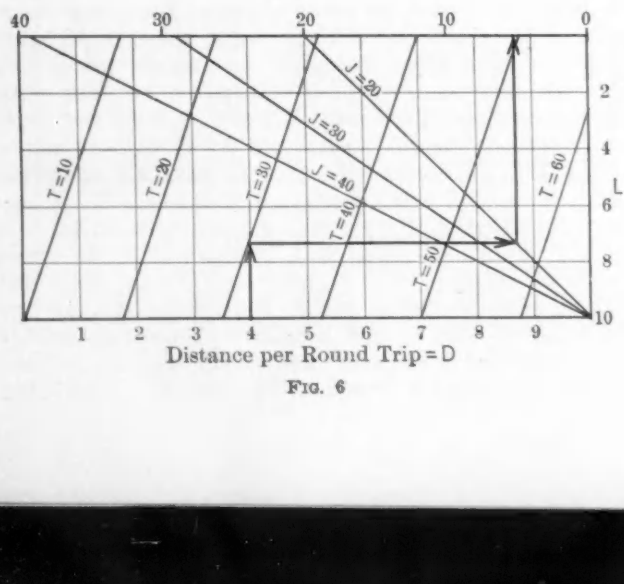


FIG. 6

CHARGE RATES

With the various factors having to do with the operation of motor trucks well in mind, it is a very short step to consider another phase of motor trucking about which there is a variety of opinions, the matter of charge rates. In general we may separate the matter of charge rates into two divisions, short-time and long-time contracts.

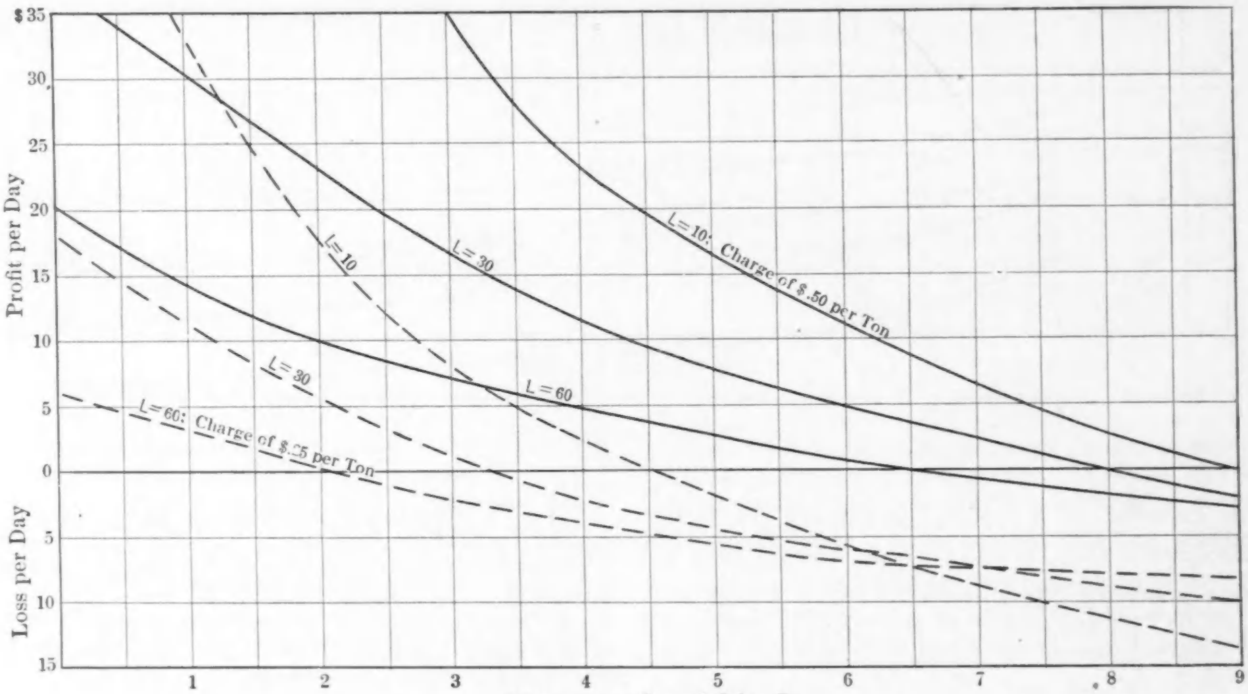


Fig. 7

The short-time contract is one of intermittent character. It may cover the haulage of a single load or extend over several hours or days, as the case may be. The long-time contract is merely an extension of the other class of hauling so as to guarantee the continued use of the truck over a considerable period of time. This is entirely irrespective of the method of charging, as it only applies to the nature of the contract, as explained above.

The following three items are available either singly or in combination as a basis for charges:

(1) Tonnage
(2) Mileage
(3) Time

It might be expected that the charge rates of motor trucks would follow closely the matter of team rates for horses. Without going into the question of team rates in detail, it is sufficient to point out that the great majority of team hauling is done on either a per ton or a per hour rate. When we desire to consider charge rates for motor trucks we must not only bear in mind the factors within the trucks themselves but also take into account the matter of competition with teams and other modes of transportation. This element of competition is a very important one and should not be lost sight of. In passing it is well to note the attitude of the railroads in establishing rates. They endeavor to fix a rate which will bring in a maximum revenue as compared with the overhead and operating expense. If a very high rate is charged the falling off in shipments reduces the yearly

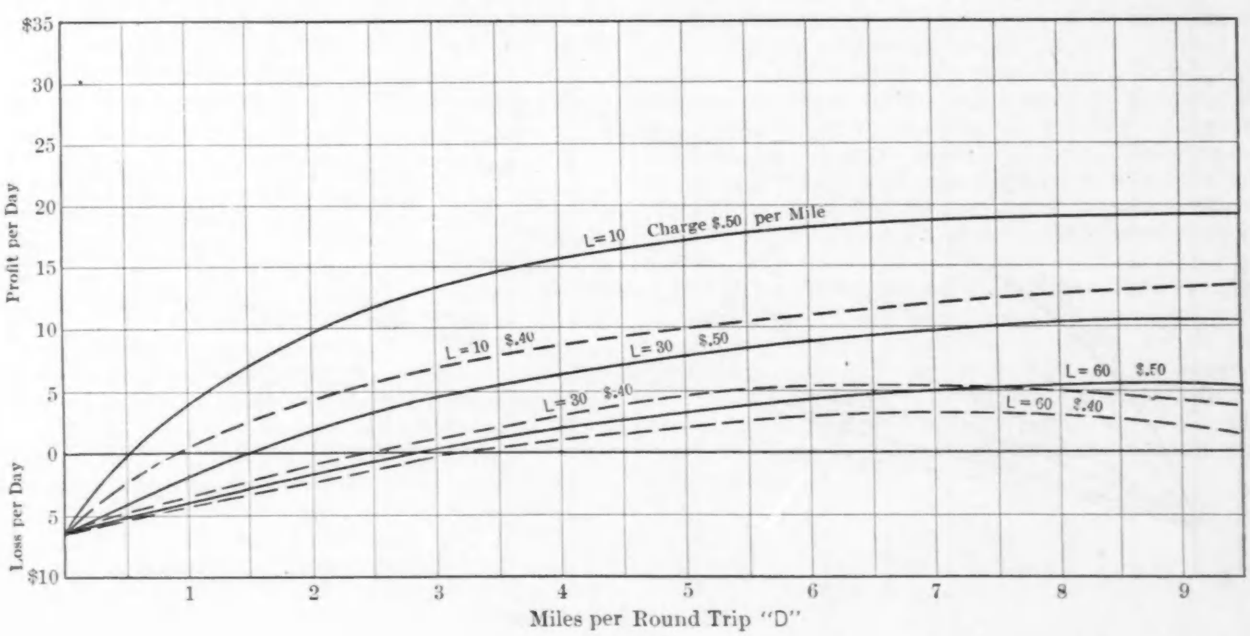


Fig. 8

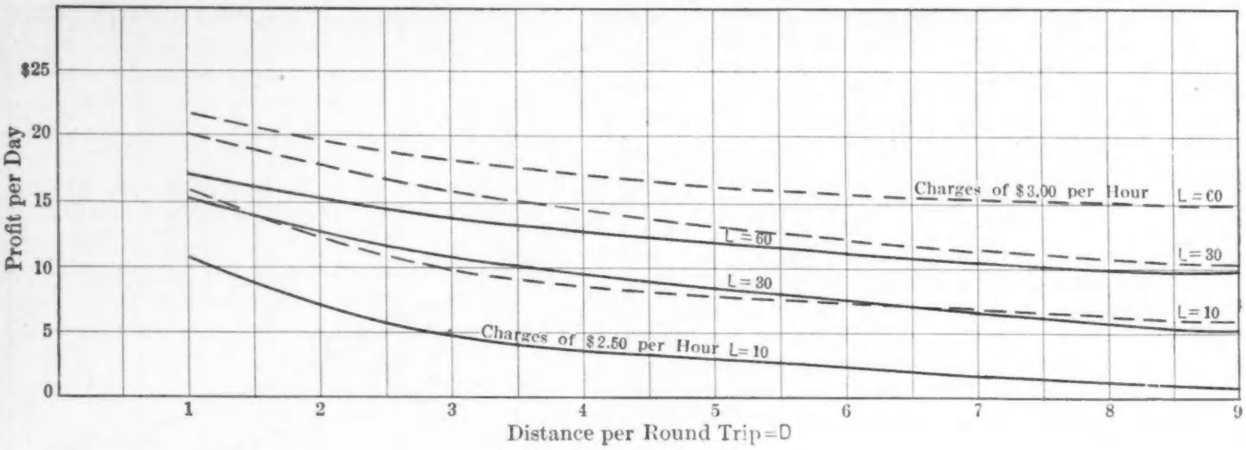


FIG. 9

earning capacity. If a low rate is charged the volume of business will not increase enough to justify the low rates.

Before analyzing the justification of a charge rate basis, let us consider certain of the existing methods in use in different lines of work and in different sections of the country.

(1) A charge of so much per day with a per hour charge for less than 1-day periods

(2) A per hour charge with an extra charge for working outside of city limits and for overtime

(3) A per day charge plus an addition of so much per mile

(4) A rate per ton varying with the particular radius of the haul divided into zone systems

To analyze this subject, we again assume certain figures for fixed charges and operating expense per mile. For this we take $6.50 per day fixed charges, and 20 cents per mile operating expense for a 5-ton truck operating loaded one way and returning empty. In view of the present increased scale of prices, the above figures are open to criticism as being on the low side. However, the conclusions reached are in no way affected by the assumed cost figures.

Fig. 7 is worked out on a tonnage basis, the solid line curves representing values of L, with loading and unloading times per round-trip of 10, 30 and 60 min. respectively and a charge basis of 50 cents per ton. The dotted-line curves show corresponding value for L but with a charge rate of 25 cents per ton. The profit per day is indicated in the left-hand scale and is obtained by subtracting the cost per day from the income per day with the assumed charge rate.

Short hauls with fast loading and unloading pay a handsome revenue on the tonnage basis. It is interesting to note the comparatively short-haul distances at which the cost is equal to the income. This is indicated by the zero line. The conclusion from this charge is easily drawn that the profit per day bears no definite relation to the cost per day. The short haul is profitable for the truck operator while the long haul is disastrous and vice versa for the truck user. Further than this, if the truck user chooses to put on less than a capacity load the profit per day falls in proportion. This is a matter entirely out of the hands of the truck owner.

Fig. 8 is worked out on a mileage basis. Two rates of 50 and 40 cents per mile are indicated for similar loading and unloading times as on the previous chart.

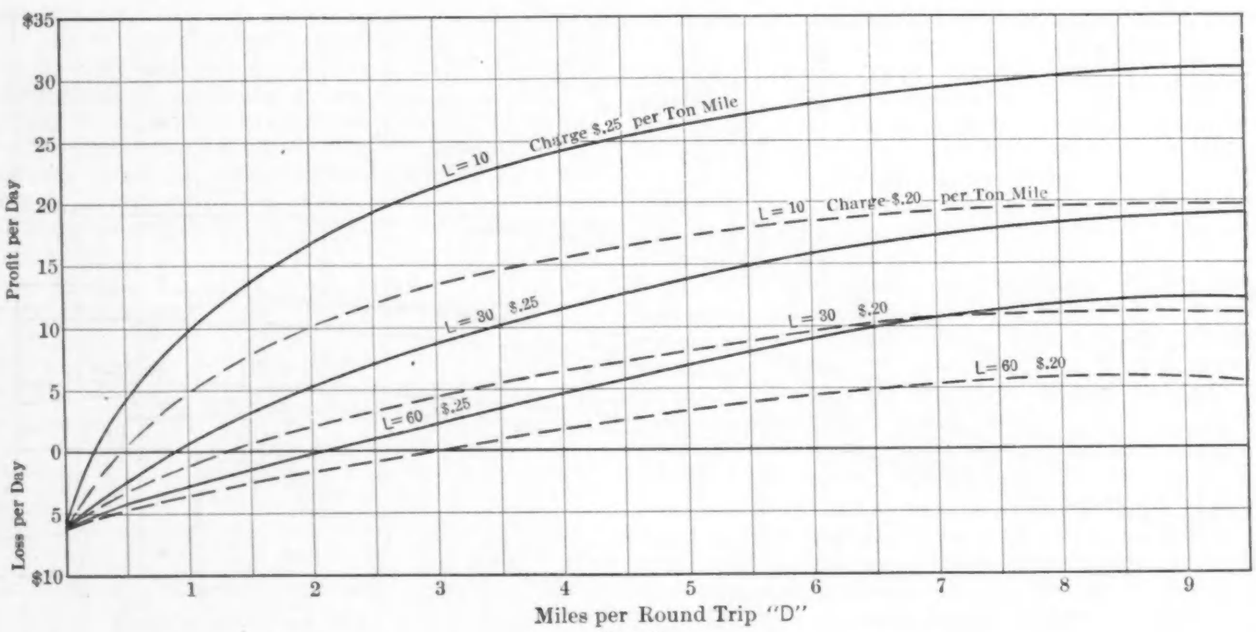


FIG. 10

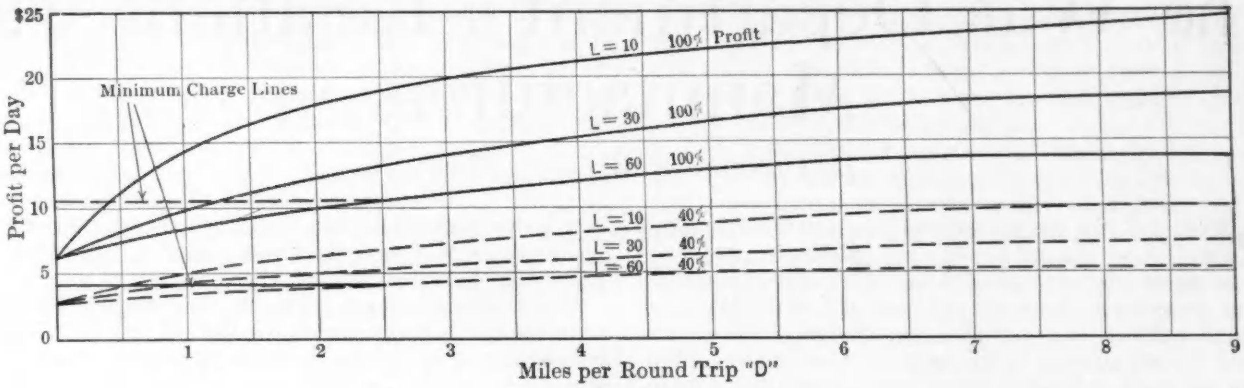


Fig. 11

In this case the conditions are just reversed in that the short haul is disastrous for the truck owner.

Fig. 9, worked out on a time basis, is extremely interesting inasmuch as it is the basis followed by most trucking companies today. Examples are worked out on the basis of $2.50 and $3.00 per hr. with similar values for *L*, as before. The remarkable point brought out by this chart is the fact that as the loading and unloading time decreases, the profit per day for the truck owner decreases. This is against all ideas of truck economy, and this chart very clearly shows the complete fallacy of charging on a straight time basis.

It is ridiculous to strive by every possible means with mechanical dump bodies, overhead cranes and driver bonus systems to cut down the loading and unloading time when by so doing the daily profit is reduced. The explanation for this is not hard to find. A truck not in operation represents merely the fixed charge, and if the owner is receiving so much per hour for the use of the truck, it is self-evident that he will receive the greatest possible profit per day by holding the truck idle as much as possible. This chart also shows that the revenue decreases as the distance per round-trip increases.

Fig. 10, worked out on a ton-mile basis, follows the same general characteristics as Fig. 8 on a mileage basis. There is, however, one fundamental difference. If the user of the truck chooses to put on less than capacity loads the profit per day will fall in proportion. This is entirely outside of the truck owner's hands and goes to show that in addition to losing money for the truck owner on short hauls, the other factor of tonnage carried makes the income more a matter of chance than otherwise.

Combined Time and Mileage Charge

The charts given so far indicate that charge rates are open to very serious criticism under different conditions of length of haul, time of loading and unloading and other factors. Therefore the foregoing charts on charge rates can be said to fall short of furnishing a rational basis for renting trucks successfully. The matter of obtaining a profit bearing a definite relation to the overhead and operating expense, similarly to the determination of railroad rates, is what we are striving for. With the basis of costs worked out on a fixed charge per day and an operating expense per mile, we are obviously in a position to fix rates on the same basis, namely on a combined mileage and time charge. If we assume a certain percentage of profit and then arrange to charge so much per hour on this basis of percentage of profit over the fixed charge and in addition have a charge of so much per mile on a basis of the percentage of profit over the cost per mile, obviously we then have a method for determining charge rates by which the truck owner receives a percentage profit regardless of the conditions of operation. The truck user is also enabled to transport his goods more cheaply when he is able to get the maximum day's work out of the truck. This economical operation or saving of time with a consequent large daily mileage is an equal benefit to the truck owner.

Fig. 11 is worked out on this basis, the solid lines representing 100 per cent and the dotted lines 40 per cent profit with different values for *L*. It is obviously advisable to fix a certain minimum daily rate, and this is worked out on a 20 mile per day basis. In other words, when the curved lines intersect the minimum charge lines, the minimum charge becomes the rate per day.

The formula for the rate per mile per day shows the relationship of the various factors, and it is only necessary to substitute the per cent profit desired to obtain an actual rate per mile, which varies with the day's mileage. This basis answers all the objections against the other methods of charging and is easy of application when once understood. A truck owner wishing to rent trucks on this basis will have very little difficulty in establishing the justice of these rates as against some arbitrary basis used by his competitors. This combined mileage and time charge is the same as indicated under the suggested third heading of existing charge rates. However, the example mentioned is not comprehensive, as it is a fixed daily charge together with a fixed charge per mile and covers the renting of Pierce-Arrow 5-ton trucks by the City of Paris for certain municipal operations.

The charge rates indicated in Fig. 11 are certainly to be preferred over any other basis for so-called long-time contracts. For the short-time contracts, due to the intermittent nature of the work, the lack of opportunity for planning effective operation and many other incidental items, it is undoubtedly justifiable to charge on a per hour basis in spite of the objections raised against this method.

The War Department's Relations with Manufacturers

By Charles V. Bacon[1] (*Member*)

PRIOR to 1914 the manufacturing establishments of the United States were, as a whole, regarded as being as efficient and on a par with, and in many instances superior to those of the rest of the world. When Germany entered the war with the Entente Powers the demand for supplies to carry on hostilities and the elimination of many imported fabricated commodities naturally caused investigation and increased production, bringing forth products and quantities previously unthought of, much of which was stimulated by the high prices paid by the Entente Powers. After the United States entered the emergency and the demand for finished material was greatly increased, it was found that our industries, which were in a high state of perfection, required teamwork and assistance to enable them to function more effectively as a whole when placed under the severest strain and requirements the world has ever known.

Defects of Pre-War Policy

The emergency demonstrated that the Government prewar policy, based on the theory that in making purchases the responsibility of the Government consisted in making legal contracts and the careful inspection and final acceptance of commodities, was fundamentally weak when applied to anything other than the smaller permanent establishments. This policy implied the ability of the manufacturer to procure his raw material and increase the production of finished commodities without the assistance of the War Department or any Governmental agency.

The enormous demand for materials to conduct the campaign necessary to win the greatest war of the world caused the fallacy of this presumption to become apparent. It was found that there was not a nucleus in the War Department which could be expanded to meet the situation. To overcome the difficulty the War Industries Board and War Trade Board were created. Manufacturers and the men controlling our industries, finances and sciences were alive to the situation and offered their services to the Government, in many instances serving without remuneration, and thanks to their splendid cooperation and genuine patriotism, the industries as a whole were operated on a basis that permitted the Government to carry out a war program of heretofore unknown efficiency.

The War Department being aware of the situation, realized that it was necessary to investigate and conduct research in connection with the industries and on standard articles of purchase, and invaluable assistance was given in this work by Dr. A. A. Hammerschlag, president of Carnegie Institute of Pittsburgh, and the very efficient organization of which he was the head. A standardization section was formed under Col. Warren R. Roberts, who was ably assisted by Major Robert Carr. Its duties were to secure standardization of types and specifications, to eliminate sizes, shades, types, finishes, etc., that did not conform to these standards and to standardize for all the Army the usual articles of purchase through cooperation with the manufacturers and thereby procure the most desirable article that was available from the standpoint of production, efficiency and economy.

Standardization committees to the number of twelve or fourteen with a personnel of 140 officers have been in operation, their activities being confined solely to the standard articles of purchase. Their method of procedure was to appoint a chairman for each general commodities committee to which a representative from each bureau of the Army was delegated. This committee was divided into sub-committees for each specific article or class of articles, and these cooperated with the manufacturers and directly with any or all bureaus of the Army, as well as had power to call in any specialist who might serve to advantage. The material standardization was then referred to the General Committee for discussion, amplification and adoption, after which the specifications were published as War Department Standard. It can be readily seen why the manufacturers desired, and even urged, a more close cooperation, as this put each and every one on equal footing.

Engineering and Standardization Branch

About the middle of January, 1918, there was created in the War Department, under the purchase, storage and traffic division of the general staff, a branch of engineering and standardization, under Col. Granville Sevier as chief, composed almost entirely of men of technical experience in chemical, engineering or manufacturing lines, which enables them to see the viewpoint of the manufacturer and work intelligently with him. Due to their military training, they are also able to apply these requirements properly to War Department needs.

The engineering and standardization branch was divided into sections, each of which was subdivided into a technical and an industrial unit. The research section was required to conduct investigations and research on standard articles of purchase with a view to improvement for Army requirements and economies and improvements in design, manufacture, material, production and packing. Practical tests were to be conducted and where possible materials of a strategic nature, with products or combinations thereof contained within our own borders, substituted. It was to supervise and coordinate research work common to two or more Army bureaus and disseminate all knowledge and information throughout the War Department and to industrial concerns in so far as it was pertinent to War Department needs.

The duties of the production section were to secure a complete list of all finished commodities procured by the Department during the emergency and the names of all manufacturers who produced them. This list also contained their office addresses and factory locations, prewar manufacturing status, maximum daily production during the war, the unit price on the last contract, packing specifications, unit shipping space, what financial aid, if any, the Government extended and a general statement as to how efficiently the contractor handled production. Complete lists of all raw materials entering into each of these commodities were obtained and from these the basic raw materials were traced back on a unit basis so that all

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commodities purchased for the Army would have the basic raw material requirements in units capable of simple multiplication to cover a military program of any size. The section was to obtain complete data covering sources of supplies in the United States of all basic raw and strategic materials and the available quantity. It was to cooperate with the war plans division to draw plans covering the protection of the incorporation of these materials in all the war plans perfected by them, keep alive an industrial inventory and inform the actual procuring divisions as to the production possibilities of the country, allocation of contracts, etc. Standard specifications to be adopted, were submitted to this section for a report regarding the effect of their adoption on production possibilities.

The standardization section was to standardize material for use of the War Department and prepare specifications and catalogs for all standard articles of purchase and to extend the scope of this work where possible beyond the immediate requirements and to provide where practicable against future urgency in the service. Particular attention was paid to existing standards as set forth by the various technical societies, with which most manufacturers are familiar. Conferences were held with manufacturers' representatives and war service committees which in the past so greatly aided in making standardization effective along practical lines.

Other divisions were designated as the inspection, exhibit and catalog and publication sections. The first was to coordinate, standardize, simplify and supervise all methods and means of inspection by or in the War Department. The exhibit section had to prepare and display types and designs of standard articles of purchase, thereby permitting the manufacturers to see and examine commodities of such various types and characters as are used in and purchased by the War Department. The duty of the catalog and publication section was to issue and supervise publication and distribution of catalogs and specifications pertaining to the Department.

Some Results of Standardization

The benefits derived by the War Department and available to the public at large, as a result of the increased efficiency, due to investigation, research and standardization will be of great future value and the cooperation of the manufacturers is in no small way responsible for many of the improvements. Some of these are cited below.

Mechanical rubber goods prior to the war were of a variable nature. They were standardized by the War Department, and in the manufacture of hose it was found that the shortage of certain weights of cotton duck presented a serious difficulty. The work done by the standardization committee and the war service committee of the Rubber Association of America resulted in the elimination of all reference to the weight of the fabric, insured quality by establishing a specified minimum bursting pressure, permitted manufacturers to use available fabric and enabled more rapid deliveries. The $\frac{1}{2}$, $\frac{3}{4}$, $1\frac{1}{4}$ and $1\frac{3}{4}$ in. sizes were discontinued and purchases confined to $\frac{5}{8}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3 and 4 in., thereby enabling greater production of the accepted types.

The requirements of the War Department for paints and varnishes amounted to over 250 different products and the shades called for were in excess of twenty-nine. After standardizing, all necessary paints, including projectile and camouflage, were included in less than 100 specifications, which also covered more economical paints for temporary structures and for use on equipment, such as limber caissons and artillery wheels, the life of which in a zone of activity is shorter than that of the paint. The shades were also reduced to sixteen in number. Credit is due the Paint Manufacturers Association of United States for its valuable assistance.

An Army division consists of about 27,000 men and has 527 mechanics who require 334 tool boxes. These, according to the old standards, occupied about 863 cu. ft. of space. After redesigning and standardizing they occupied about 211 cu. ft., were superior for Army requirements and enabled the Class B military motor truck to carry an average of about 798 new-style, as against 250 old-style boxes. In addition an actual saving of about $32 per box, in ship cargo space, was effected.

Comprehensive research has been conducted on subsistence supplies. The dehydration and evaporation of fruits and vegetables resulted in enhanced security against loss in shipment, bringing additional millions of pounds of food within the reach of our troops in Europe. Likewise on refrigerator products, investigations resulted in a new method of trimming carcass beef, and its complete boning saved ship cargo space and enabled us to reclaim the by-products, not least of which was the fertilizer agents to help replace our shortage in the potash supply.

The number of utensils required for cooking and camp equipment was very large, and, due to the shortage of tin, it was necessary to use additional amounts of stamped metal ware. Standardization eliminated undesirable types, secured a better grade of enamel coating and effected a saving of strategic material amounting to about 20 tons per month.

Almost unbelievable savings were made in shipping and packing, due to research and study. The improved crating of a single shipment of 2000 horse-drawn ambulances was calculated to effect a saving of 300,000 cu. ft. of shipping space, roughly equivalent to the carrying capacity of a 5000-ton cargo boat. On 6500 water carts, improved crating resulted in a saving of 279,000 cu. ft. of space. This cargo space being worth $6 per cu. ft., made the saving amount to over $1,500,000.

The advantages of baling for certain commodities, over casing or boxing, have been given careful study, and much credit is due to Major Abercrombie for some of the wonderful accomplishments along these lines. It is estimated that by improved baling methods the War Department has saved about $80,000,000, and during an emergency it possesses a decided advantage, as the covering material, on arrival, is of suitable nature and size to be made into sand-bags readily.

Other important features are a large reduction in injuries to men handling baled goods as compared with cases and a reduction in cost from about $4 per case to an average of 80 cents per bale. The saving of floor space which is approximately 17 per cent and the ability to handle about twelve times as much baled as cased goods should also be mentioned in this connection. With shoes it was found that 24 pairs could be baled in less than 4 cu. ft. as compared with the old-style packing in cartons and cases where 20 pairs required over 6 cu. ft.

In conclusion let us bear in mind that from the facts outlined it should not be thought that these improvements are solely for the War Department's benefit. It is the earnest desire of the engineering and standardization branch of the War Department to cooperate fully with the manufacturing industries so that they may profit by the results achieved and to assist them in maintaining the high standards of which only a brief *résumé* has been given.

Activities of the Base Section, Motor Transport Corps

By LIEUT. COL. K. G. MARTIN[1] (*Member*)

Illustrated with PHOTOGRAPHS

THE activities of the Motor Transport Corps in France originated on the arrival of four motor-truck companies from Fort Sam Houston, Tex., which landed at St. Nazaire on June 27, 1917, and immediately commenced operation as a transportation unit. Within 30 days thereafter touring cars and ambulances began to arrive in considerable number. These vehicles had to be uncrated and set up and made ready for operation. The truck companies had to handle this work in addition to their other duties.

EARLY WORK

The work during the winter was of the most grueling and difficult nature, the men working practically 24 hr. per day under terrible conditions of cold and mud, moving freight from the docks, hauling personnel, getting the trucks and cars off the boats and making them ready for service, and establishing their camp, motor park and shops, which were located on Ocean Boulevard fronting St. Nazaire Bay.

A CHARACTERISTIC MUD HOLE ON A FRENCH ROAD IN THE VICINITY OF THE BASE SECTION

In the early spring of 1918 additional personnel arrived and operations were assuming large proportions. The activities of the Motor Transport Corps were thereafter separated, the personnel and vehicles engaged in operation remaining at the original base, while a new very large park was laid out under General Rockenbach, then colonel in command of the base section. This plant was about 2 miles out of town on the Rue Ville Martin, and here was carried on the handling of all vehicles arriving at the port as freight which had to be assembled and made ready for dispatching to the front. By March 1 convoys began to move out.

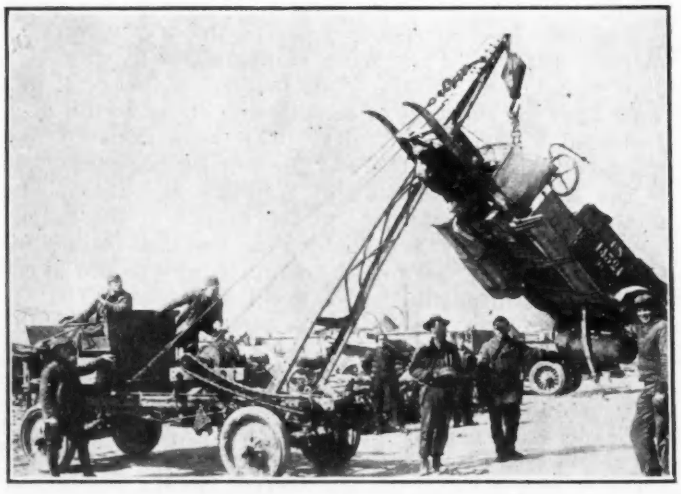
In the meantime activities throughout the base section were constantly growing and additional operating garages and reception parks were established in rapid succession at Camp 1, at Montoir, at the engineer camp and at other important centers throughout the base, such as Savenay, Nantes, Angers, Samur, Meucon, Coetquidan, etc. A school for drivers was established at Le Baule. The reception park at Nantes was the second largest in the base.

THE HANDLING EQUIPMENT REQUIRED AT THE DOCKS AFTER THE CRATED TRUCKS WERE RECEIVED FROM THE SHIPS FOR SUB-ASSEMBLY AND TOWING TO THE MAIN PLANT FOR FINAL ADJUSTMENT AND TUNING UP

TERRITORY COVERED AND PERSONNEL

As organized at the time the armistice was signed the Motor Transport Corps had in service in Base Section No. 1, which covered five French departments and 10,000 square miles of territory, fourteen separate plants and stations, a personnel of over 7000 officers and men, and over 3000 motor vehicles. The personnel was composed almost exclusively of men formerly in garage or automobile factory work in the United States and represented a very high-grade and highly-paid civilian class. The men held practically every record with regard to the transporting of troops, hauling of freight, production of motor vehicles and size and speed of delivery of convoys.

Upon leaving the docks and city of St. Nazaire one



ONE OF SEVEN DERRICK TRUCKS CONSTRUCTED FOR RECEPTION PARK OPERATION AND GARAGE EMERGENCY SERVICE WORK, ALL MATERIAL BEING SALVAGED FROM DAMAGED EQUIPMENT

[1] Chief transport officer, Base Section No. 1, Motor Transport Corps, A. E. F.

passed along the Ocean Boulevard, which skirts the Bay of St. Nazaire, and in front of the Motor Group and Headquarters Garage. This was probably one of the largest Motor Transport Corps service transportation organizations in France. From this station and its subsidiary garages were operated 900 motor vehicles serving the entire St. Nazaire and Montoir district. It had a service repair shop system, a large gasoline filling station, washing racks, painting sheds, a 250-ton tire press for pressing on truck tires, its own generating and lighting plant, a rapid fire-dispatching system and hundreds of other minor utilities which make up and maintain an efficient garage system. The plant and camp were operated by about 1200 men, the camp being well situated on sandy soil under pine trees and having a complete and adequate fire-fighting system, recreation center, etc. Each day one of the companies was withdrawn from service. The men drilled in the morning and were inspected; in the afternoon the vehicles and equipment were inspected.

At the engineer camp a separate Motor Transport Corps establishment was maintained for the special service of the section engineer and some 300 vehicles were operated, the majority being engaged in construction and road repair work, and including special types, such as sprinklers, 10-ton trailers, etc.

Motor Reception Park

Motor Reception and Overhaul Park No. 701 was the largest motor reception park in France. It was the first to be established and was manned by 125 officers and 3000

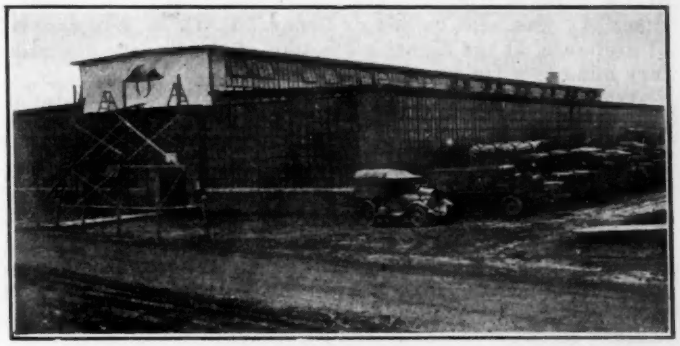
A Glimpse of One of the Parking Areas at the Base Section

men, labor being supplied by German prisoner labor companies, which had their own camp within the park area. The function of this park was to receive new vehicles from the United States for assembly and shipment to the front and wornout vehicles from the front or Service of Supplies for overhaul and reissuing.

The vehicles received from the United States came packed in pieces in 6-ton crates and were unloaded at the docks, whence they were sent to the motor storage yards at Montoir. From Montoir they were drawn, still in crates, as fast as required to the sub-assembly yards at Parc de Means, where they were unloaded by steam crane equipment, sub-assembled and put in condition for towing to the main park by 300 men permanently quartered at Parc de Means. Upon arrival at the main park the vehicles went through various processes and shops where they were put in perfect condition and reported to the Motor Transport Corps Headquarters at Tours and held ready for shipment overland in convoy formation at a moment's notice.

The area under motor reception park control covered 52 acres and included a track system, steam crane equipment, ninety-seven shop, barrack and auxiliary buildings and a large consolidated mess hall officially designated the model base section mess hall. The heavy truck shop alone had fifty-three pieces of machine-tool equipment, and in the plant there were many unique and highly specialized devices for use in the assembling, repairing, testing and tuning up of motor vehicles. Many of these original devices were standardized for use.

In each working day 1200 motor vehicles passed the



A Building Which Was Shipped from the United States and Erected as One of the Machine-Tool Shops at the St. Nazaire Motor Reception Park

gates of the motor reception park. It has produced in a single day-shift 162 motor vehicles; in a single week, 737, and in a single month 2702. Up to March 1, 1919, the astounding number of 25,891 motor vehicles were produced at this plant, representing one-third of the motor vehicles put into the service of the American Expeditionary Forces. Together with the motor reception park at Nantes this base section produced over 40 per cent of all the motor vehicles in the service of the American Expeditionary Forces in France.

As well as producing the motor vehicles, the personnel on duty at the park was used in the delivery of these vehicles at the front. On Christmas Day, 1918, 360 trucks and cars were checked out of the issue park, complete tool and service equipment was issued to them, they were parked in convoy formation, drivers and officers were assigned and the vehicles were dispatched and ran continuously night and day until they reached the front. One convoy personnel made two complete round-trips of 450 miles each in 14 days, the return journey in each case being made by train. Other convoys were dispatched which traveled overland a distance of over 800 miles. The convoy service continued to deliver vehicles at the front until and for a short time after the army had reached its base at Coblenz.

Features of the Reception Park

There were several other interesting features in connection with the reception park at St. Nazaire. The entire plant except the large steel and glass Austin main shop was constructed of scrap lumber in which the vehicles had come crated, the construction of the plant having gone on simultaneously with the production work. At one time about 150 French women were employed, a number of them on the assembly of Fords; they turned out as many as 60 complete Ford cars in a day.

At the motor reception park at St. Nazaire was located the office of the chief motor transport officer of the base section, from which the administration and operation of the motor plants and garages serving the great Montoir warehouse project and force in Base Section No. 1 were directed.

AUTOMOTIVE ORDNANCE EQUIPMENT

THERE is little if any question that even in the complete sense motorized field artillery is here. That is, this important event in automotive development has come to pass and is not in any way a matter of futurity. There are, of course, those who still advocate the retention of horse artillery equipment haulage under certain conditions, and opinion which deserves consideration is divided to this extent. The merits of the horse will naturally be advanced as unique for some time. As was said by Major-General C. C. Williams, chief of ordnance, at the Summer Meeting of the Society, the military mind is a rigid one.

Aside from any doubt as to complete artillery motorization being here or feasible it is obvious that a vast amount of work is at hand in connection with the design and production of tanks, tractors, mobile repair shops and the like for use in the Ordnance Department. It is well known that our Ordnance Department not only took as early steps as were taken in any country toward field artillery motorization but used and developed during the war a great amount of automotive equipment of commercial and Government design produced in this country.

Assistance of the Industry

The policy of the Ordnance Department in its development and production work is to secure the advice and assistance of the industry to the greatest extent possible. Individuals and companies are asked to submit designs and will in turn be invited to submit bids for the production, at first, of sample models of approved designs. This wise and liberal method will it is believed be of great and increasing effectiveness. The Ordnance Department deserves great credit for inaugurating the policy, which in one of its most important phases contemplates the availability and use of the best automotive engineering talent in the country for the common good. The reliability of the mechanical equipment must be equal to that of the horse. Given this reliability there is no doubt that the mechanical equipment would be more effective than the horse; not forgetting that on account of the frailty of the horse and the various difficulties of maintaining him in acute war operations, the mechanical equipment is now in many respects more reliable than the horse.

The Ordnance Department will have the full cooperation of the Society of Automotive Engineers, many of whose members worked with the Ordnance Department in a remarkably helpful way during the war. A committee of the Society is now at work with the Ordnance Department and will hold meetings regularly for the purpose of formulating advisory recommendations and considering engineering questions submitted to it by the Ordnance Department. At the sessions of the committee held in Washington on Sept. 15 and 16 there were present: Major-General C. C. Williams, chief of ordnance; Brigadier-General S. D. Rockenback, chief of the tank corps; Col. C. L'H. Ruggles, chief of the technical staff of the Ordnance Department; Col. L. B. Moody and Col. James B. Dillard, and the following members of the S. A. E. committee: Herbert W. Alden, chairman; W. G. Wall, Dent Parrett, G. W. Dunham and Coker F. Clarkson, secretary. President Charles M. Manly and Past-president C. F. Kettering of the Society, are also members of the Committee.

The Ordnance Department will maintain offices at Syracuse, Cleveland, Detroit and Peoria, as well as at Rock Island and Aberdeen. In connection with the previous announcement as to there being available at Rock Island for the inspection of automotive engineers samples of motorized apparatus used by the Ordnance Department at the present time, it is intended that as complete, if not more complete, an exhibit will be maintained at Aberdeen, Md.

Improvement of Tanks

Specification work is now being conducted in connection with further production of tractors, trailers, tractor caissons and some special apparatus. Various matters in connection with the design of tanks are under consideration.

There is no doubt of the great value of tanks in warfare. They are an answer to the machine gun. As in other automotive vehicle design the questions which arise in formulating specifications for tanks relate to overall size, amount of internal space, power, capacity and running speed. There are, of course, numerous other matters involved by virtue of the characteristics of tank operations, such as balance and ground pressure. The powerplant is, obviously, a vital feature of the tank. The tank now has one-man operation as a feature, whereas several men were required to drive the first European models. Generally speaking it is to be expected that tanks and tractors will not only be equipped with various types of accessories developed and to be developed, but be lighter, faster and less noisy. One interesting phase of tank construction is the feasible life of the machine under strenuous conditions so far as the powerplant is concerned. There is no doubt that the task of an engine in a large tank is a very severe one. Our Army had, however, a goodly number of tanks in operation for a considerable time during the war and these were right at the front when the armistice was signed. The tanks are not an independent arm of the service in that they require infantry support. One of their particular functions is to clear the way for the infantry, particularly with regard to enemy machine guns. There is no doubt that the tanks are a decidedly effective humane element in the saving of men in war engagement.

The Ordnance Department is proceeding in a way that deserves the unqualified support of all in that it means the maintenance of adequate preparedness against war possibilities. Models of the various automotive ordnance apparatus needed must be ready for instant production at any time. The design, testing, checking and production of any such models require at least several months' time, which is entirely too much in an emergency in any proper view of preparedness. It is stated that some of the European models were not produced inside of 18 months. Preparedness is vitally necessary, as to both personnel and materiel. It appears certain that it takes longer to produce proper materiel of the kind under discussion that it does to train and organize personnel for the respective purpose. This is one of the main actuating reasons for the Ordnance Department proceeding in the manner which has been indicated.

Motor Transport Corps Training School

ON Sept. 5, the vocational training school of the Motor Transport Corps at Camp Holabird, near Baltimore, Md., was formally opened by Secretary of War Baker. This inaugurated a new era in Army educational policy and is the first of four great training camps planned by the Corps. The three other schools, which will commence operations as soon as completion of pressing repair work and the availability of instructors permit, will be located at Camp Jesup, Atlanta, Ga., Camp Normoyle, San Antonio, Tex., and Camp Boyd, El Paso, Tex. These four locations were chosen because they were great Army automobile production and shipping centers during the war and as such have considerable equipment available. While the main function of the schools is to train the personnel of the Motor Transport Corps, it is planned to extend the facilities so as to train selected officers and enlisted men from all other branches of the Army.

Experience in two extensive military operations has shown that even under the best road conditions skilful maintenance and operation are vital to any prolonged military effort and as the road conditions become worse the importance of these factors steadily increases. In peace time the situation differs only in that financial economy becomes the impelling motive instead of economy in man power and human life. Men skilled in automotive vehicle operation and repair do not exist in anything like adequate number for the requirements of civil life alone. At the present time they are not being trained rapidly or well enough to meet the industrial needs aside from the demands of the Army and other branches of Government service. For that reason really skilful automotive mechanics command wages that render them absolutely unobtainable by the Army and it therefore became necessary for the Army to enter the field of vocational training and establish schools, as there was no other way to secure trained personnel. The vocational training proposed will not only provide a sufficient number of trained men to handle all Army motor transport in times of peace but will, as the men are discharged at the end of their enlistment, provide a great reserve of trained men in civil life who will be available for service to their country in war. In addition a consideration almost as important is that the motor Transport Corps will continue to send into civilian life large numbers of men so well trained that they will be able to earn good wages and be a benefit to the automotive industry at large.

Proposed Training Courses

The training plan is a series of courses in vocational schools alternating with periods of supervised production work in the shop and supervised work in service park and operating units in the field. It is not the old apprentice system in which the pupil gets his instruction incidentally from other mechanics but real schooling under trained teachers, in which the time of the pupil is wholly devoted to receiving instruction and training. This course will extend over 4 months. The first regular class, which commenced work on Sept. 2, is composed of enlisted men. The regular course for officers will extend over 4 months also and commence Oct. 1.

Since the schools are created primarily for the bene-

A Portion of the Machine Shop at the Camp Holabird School

fit of the Motor Transport Corps and are the means of making the latter efficient, it is naturally not contemplated that a large part of the enlistment period of each man will be devoted to school work. Every man will receive training of some sort, the amount and type being necessarily conditioned by his ability to profit by it. In the case of an unskilled man of low intelligence, the training might take as little as 3 per cent of the total time of his enlistment. For the average operating personnel it is expected that the training will consume 8 or 9 per cent of the enlistment period. In the case of the average shop personnel 12 to 13 per cent of the time will be devoted to training. The skilled mechanic of the foreman grade would receive training during about one-quarter of his enlistment and in the case of men of the superintendent and officer grade it would be 50 per cent.

Five graded courses of instruction will be given at the school. These are known as the schools of the soldier, the military chauffeur, the mechanic, the inspector and foreman and the automotive engineer. The first is a 4 weeks' course taken by every man on entering the Corps, or as soon as possible thereafter. The aim is to teach the newly enlisted civilian how to live like a soldier rather than to impart any real technical education. In this time the recruit is observed, graded by psychological and trade tests and at the end is ready for assignment according to the results of his performance.

The training in the school of military chauffeur will consist of an 8 weeks' course designed to produce a semi-mechanic who is not only an efficient driver but able to safeguard both vehicle and load by careful inspection. He will be able to make emergency repairs and to differentiate between those conditions which should cause complete stoppage of operation and those which merely call for repairs when convenient.

The aim of the school of the mechanic is to produce men of all the fundamental trades who, under supervision, can overhaul and repair any standard type of motor truck or passenger automobile. In this school there are twelve separate courses covering as many different trades or groups of trades as are usually handled together in commercial establishments. These cover machinist, automobile mechanic, ignition and carbureter work, battery repair, welding, blacksmithing and springmaking, radiator and sheet metal work, wood working, trimming and painting, tire repairing and wheelwright work, warehousing and the issue of parts and salvaging. As far as possible each man will select a course or will take the one in which he has had experience. These courses will last 16 weeks each and are intended to prepare a man to enter a given line of work in commercial life.

School of the Mechanic

The men taking the machinist course will have practice in such work as operating, grinding, milling and drilling machines and lathes and assembling engines, transmissions and axles. The automobile mechanics' course is intended to turn out men fitted to occupy positions in service stations. Other work these men will be qualified to do is location of trouble, overhauling cars and assembling engines, transmissions and differentials.

Men qualified for positions in electrical service stations will be produced by the ignition and carburetion specialists' course as well as that for battery repairmen. Graduates of the former course can also locate trouble and serve as inspectors of electrical installation at factories and at battery stations. The latter course is intended to provide the men capable of building and repairing storage batteries as well as of installing lighting and starting systems in which the battery furnishes the supply of current. The welders' course aims to turn the men out capable of repairing damaged automotive equipment by welding, as well as machinery salvage station men, bridge and structural steel workers, shipyard welders and service station men.

The sheet metal and radiator course is designed for recruits who have had experience as automobile service station men or worked in plants manufacturing metal bodies. Experience in sheet metal forming, the manufacture of art metal goods and the brazing and sweating of metal parts, would tend to qualify a man for taking this course.

The tire repair and wheelwright course is intended to turn out experienced garage men as well as men capable of serving in tire agencies and service stations. Truck wheel men in tire factory branches are also trained in this course. The blacksmith and springmakers' course is designed to produce automobile shop blacksmiths and men for street car shops.

The woodworkers' course enables men to qualify as outside carpenters or carriage and automobile body repairmen in service stations. Graduates of this course are also fitted to work in an upholstery and top shop. Painting and to some extent body finishing are also open to recruits pursuing this course.

The warehousing course as its name indicates has to do with the handling of spare parts; it is also designed to train men for work along this line in car agencies and automobile factories.

Advanced Courses

For those men who complete one or more of the courses outlined above and have had some production experience in shops, the school of the inspector and foreman will be open. This course also covers 16 weeks and is designed to round out and fill in the gaps in the candidate's previous training and experience in general automobile mechanics' work. It is intended to provide training in the handling of men as well as teach the student how to survey cars and trucks turned in for repairs and determine what and how much work must be done to render them fit for service again. The ability to give intelligent and graphic instructions to the shop foremen regarding these repairs should follow as a result of this course.

For those students who show marked efficiency in completing the school of inspector and foreman a 36 weeks' course at one of the high-grade technical schools of the country is planned. This is known as the school of the automotive engineer and is designed to perfect the knowledge of practical automotive engineering so that the graduates can act as instructors in the schools of the Motor Transport Corps and also to carry out and plan for the changes which occur from time to time in motor-vehicle construction. The work covered by this course includes a review of mathematics and its applications, a study of the principles of chemistry, machine shop practice, gas engine laboratory work, business efficiency, thermodynamics and fuels, elementary metallurgy, machine shop management and elementary electrical engineering.

Patents and Inventions and How to Handle Them

By B. M. Kent[1] (*Member*) DETROIT SECTION PAPER

IN presenting a paper on the subject of patents, it is my purpose to deal only with such phases of the subject as I have found in my practice of patent law to be of importance to the engineer in his every-day work. Many of you, no doubt, are familiar with patent matters and have frequent dealings with patent attorneys, but a brief discussion of some of the fundamentals of the subject may nevertheless be profitable.

What is a patent? We all have some idea as to what a patent is, but I doubt if more than a few of those present could define one accurately. It is a grant by the Government of an exclusive right. Patents are granted for lands, inventions, discoveries and other subject matter, but as the term is commonly employed, it has reference to inventions. This form of patent, or more technically, letters patent, as granted by the United States Government, is the exclusive right to make, use and sell an invention or discovery for a period of 17 yr.

Curiously enough, the terms of a patent grant do not mean what they seem to say, for while the patentee is granted "the exclusive right to make, use and sell his invention," he does not actually, by virtue of this grant, acquire any right whatever to make, use or sell his invention. I believe that the average layman thinks he can proceed to make, use and sell his invention once the patent is granted, and I frequently encounter the idea that a patent is *necessary* to exploit an invention.

What a Patent Means

The real meaning of the patent grant is that the patentee is given the right to exclude others from making, using and selling his invention. Obviously, the rights of a patentee in a certain field of invention are subject to the rights of his predecessors, who, like himself, have been granted the right to exclude others from making, using and selling their inventions, and the later inventor may have made only an improvement and this improvement may employ the principles of the invention of an earlier patentee, and thus infringe the rights of the latter.

You may well inquire how a patentee is to know whether he can make, use and sell his invention, if his patent does not give him this right. The answer to this is that he should look up all prior patents related in any way to his invention and thus ascertain if there be any infringement. For the purpose of making such investigations, the Patent Office maintains a complete file of all United States patents, arranged in classes and subclasses of invention. These patents are accessible to the public and suitable facilities are provided for their convenient examination. This system of patent records is analogous to the systems of land title records maintained by every county. Before investing in real estate it is customary to have the records searched to ascertain whether there are any prior rights that would be infringed. The same precautions should be exercised in regard to patent rights. The Patent Office does not maintain a force for making such investigations or reporting on questions of infringement, and the work is usually done by the patent lawyer.

About 1,290,000 patents have been issued by the United States and these are divided into some 275 general classes and thousands of sub-classes. The sub-classes are generally so differentiated as to restrict to rather narrow limits an investigation with reference to any particular subject.

Commercially Workable Patents

It is well known that only comparatively few of the patents that are issued are worked commercially, and yet many patents that are not worked are of great potential value. Sometimes valuable patents are bought up and suppressed for commercial reasons. Others lie dormant because the patentee is not able to enlist the support of the necessary capital. The majority of patents that lie dormant, however, are in this condition because of their utterly impracticable nature. Nevertheless, many of these impracticable patents contain ideas that are capable of rational development if placed in the hands of practical engineers, and because of this I recommend to you a wider use in your work of the vast store of information that is contained in them. There are numerous ways in which you can use this information as a means for promoting efficiency in engineering and experimental work.

By maintaining in your engineering departments files of the classes of patents relating to the lines of work in which you are interested, and by consulting them, you can add to your knowledge of the commercial development of these various lines some knowledge of the numerous related ideas that, for one reason or another, never had a commercial development. Frequently the story of the development of an invention which may have required long study and the expenditure of large sums of money can be obtained from a series of patents. When an engineer has a problem in design to work out he can very often get many helpful ideas from patents and information that otherwise it would require costly experimental work to procure.

Your patent lawyer will be able to assist you in the making up of files of patents relating to your line of work, and in connection with such files I suggest that you should receive regularly the *Patent Office Gazette*, as this contains a complete list of the patents issued each week and will keep you informed.

Invalid Patents

Many of the patents that are issued are wholly or partly invalid, but the determination of this question should be left to the patent expert. The courts have in the past so frequently declared patents to be invalid that there has resulted a rather widespread disposition among business men to ignore patents. This disposition is of more danger to the possessor than to the patentee, because it has a tendency to induce hasty and ill-advised conclusions that sometimes result in passing by opportunities to acquire valuable or necessary patent rights under most

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favorable conditions, and may also result in wasteful and unnecessary litigation. I recall a recommendation made a few years ago by one of the leading lawyers in the patent profession to one of the large automobile manufacturers to purchase a certain patent of questionable validity because of its nuisance value. The patent could be acquired for a modest sum, and had the owner brought suit against the manufacturer the cost of the defense would have been considerable, the time of valuable employes would have been taken in connection with the suit and in the end there was the chance that the patent would be sustained and very large damages collected. The purchase of the patent was a simple solution of the whole matter and when acquired this manufacturer was able to put it away and forget it. In another similar case a manufacturer chose to ignore a certain patent, was sued and in a comparatively short time was confronted with a judgment amounting to many times the price originally asked for the patent.

Patents should not be ignored without due consideration, and questions of infringement should be referred to a patent lawyer for expert advice. Sometimes it is found on investigation that no actual infringement exists; sometimes there is an apparent infringement which may be cleared up by careful study of the scope of the patent. Such a study involves a consideration of the record of the application for the patent and may involve an investigation of prior patents, both foreign and domestic, but this work should always be done by a patent expert.

Since the patent application is the basis of a patent and has very much to do with its validity, I am going, at the risk of perhaps tiring you, to tell you something about it.

Who May Secure Patents and How

Many of you probably have a great deal to do with patent applications, perhaps more with the applications than with the patents, and I propose to outline briefly what an application is and describe some of the fundamentals of the law so that those who are not familiar with them will be able to talk intelligently on the subject.

A patent may be obtained by any person, and I quote from the law on the subject, who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof, not known or used by others in this country before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than 2 yr. prior to his application, and not in public use or on sale in this country for more than 2 yr. prior to his application, unless the same is proved to have been abandoned.

The patent is procured by filing a formal application therefor in the Patent Office and this consists of a petition to the Commissioner of Patents, praying for the issuance of a patent, a description of the invention in such form that it fully discloses the invention so as to enable those skilled in the art to which it appertains to practice it, a definition of the invention in the form of one or more claims, an oath in the form prescribed by law and a fee of $15. The description of the invention is usually accompanied by drawings illustrating the manner of making and using it.

The preparation of the description, drawings and claims should be done by a patent lawyer and if possible by one qualified in the line to which the invention relates. The drawing of the claims is usually the most difficult part of the work of preparing an application and requires the most skill. This is true because the claim must define the invention broadly over what was known at the time the invention was made, and in such a way as to include as many different structural embodiments of the invention as possible. You will thus see that the patent lawyer must not only define what he has before him, but also the unknown future developments of the invention.

To do the most efficient work, a patent lawyer should specialize in particular lines, just as engineers do, and in selecting a patent lawyer for your work you should be governed by the principles that apply in the selection of an engineer, as the value of his services will be in proportion to his skill and experience in your line of work.

A patent for an invention may be good, bad or indifferent and usually reflects the skill of the lawyer who procures it; hence, you should not select a patent lawyer without having knowledge of his qualifications for your particular line of work and should see to it that your work is handled by the person whom you select and in whose ability you have confidence. There are patent sharks to beware of, as well as medical ones, but the one is as easily detected as the other, because their business methods have so much in common. I have seen numerous patents for very meritorious inventions in which the attorney showed that he had very little knowledge of the subject, and the patents as issued were practically worthless. Sometimes another attorney is able to remedy a situation like that, but a man who has had experience with patents will usually be very careful in selecting his attorney, because if he has had his right to a good invention practically forfeited by poor work on the part of an attorney he realizes the importance of skill and experience in describing and properly clearing an invention.

An application for a patent must be made in the name of the inventor and must be signed by him. When filed in the Patent Office it is given a serial number and date, and passed on to an examiner, who considers applications in the order of their filing and first determines whether they conform to all the requirements of the law in matters of form. The description of the invention is then carefully read and the examiner familiarizes himself thoroughly with the invention. He then considers the claims and proceeds with a search in the related classes of invention to determine whether the applicant is entitled to what he has claimed. Each examiner passes upon all the applications relating to certain classes of invention and is supplied with copies of United States and foreign patents relating to these. Through repeated searches in his classes an examiner becomes very expert in these lines.

Upon completing his consideration of an application, if the examiner finds that it is not allowable in the form presented he writes a letter calling attention to the informal matters and rejects such claims as he considers not patentable, citing prior patents or other references as the basis for his rejection. The inventor is allowed 1 yr. within which to answer the examiner's letter and his response must cover all the points referred to by the examiner. If such response is not made within the year allowed the application becomes abandoned.

Now your patent attorney will have occasion in connection with your application to show you these letters as he receives them from the Patent Office, and his reply usually has to be based on the information given to him by you, the engineer being supposed to know more about the invention than the attorney.

In his answer to an examiner's letter the attorney, acting for the inventor, makes such amendments to the application as he thinks are necessary, and if he con-

siders that the rejection of any of the claims is not proper on the references cited, an argument is presented in connection with the amendment for the purpose of pointing out why the references do not disclose what is specified in the claim. A series of examiner's letters and amendments may thus be exchanged before the application reaches an allowable form.

If the attorney does not agree with the examiner in regard to a material objection to the application an appeal may be taken for the purpose of having the question decided by a higher tribunal, and provision is also made for further appeals to the Commissioner of Patents and to the Court of Appeals of the District of Columbia, if the attorney considers it necessary in his effort to secure a patent of the scope to which he thinks the applicant is entitled.

If two or more inventors simultaneously claim an invention and the examiner considers claims made by either or both to be allowable, a proceeding known as an interference is instituted for the purpose of deciding which of the rival claimants is the prior inventor and entitled to a patent. Interference proceedings are quite common and especially so on lines in which rival interests are doing active development work. There have been interferences in some of the most famous inventions, as, for example, the telephone. In this case it was between applications made by Bell and by Gray, and after a long drawn out controversy the patent was finally awarded to Bell and became the basis of the famous Bell telephone monopoly. After the patent is granted the official application record is open for public inspection and printed copies of the patent may be obtained from the Patent Office.

Assignment of Patents

The invention and the application, as well as the patent, are in law treated as personal property and subject to sale and transfer, the same as any other personal property, such as stocks and bonds or a business. The usual forms in which patent rights are transferred are shop rights, licenses, territorial grants and assignments of the entire or of fractional interest in a patent.

It is customary, in the case of engineers and other employes of manufacturing companies, for the company to take an assignment of any invention made in connection with its products or manufacturing methods and developed with the use of its facilities or at its expense. Such assignment is usually taken at the time of execution of the application and for a nominal consideration, although it is sometimes made after the application has been filed in the Patent Office or after the patent is issued. As the usual form of assignment transfers to the company the entire right to the invention and the patent, an employe sometimes enters a protest. However, the great majority of patentable inventions made in connection with the work of a manufacturing company are mere improvements, and the work of the engineer or other employe who is given the credit for making the improvement is to a large extent involved with the work of other employes of the company; hence the actual devising of the improvement is only a link in a chain which involves the company's whole organization.

It may be of interest to you to know that the assignment of a fractional interest in a patent carries full rights unless it is coupled up with some contract under which the entire interest in the patent must be dealt with as a unit. For example, if A owned a patent and assigned to you a one-eighth interest in it, retaining seven-eighths for himself, you would really have just as much of the rights as he, because you are not bound under the law to account to him in any way nor does he have to pay you one-eighth of anything he may make from the use of the patent. You could assign a one-hundredth interest in the patent and it would carry just as much in the way of rights as the interest you retain. So in that way an assignment of any interest whatever is an assignment, and in the absence of some special agreement, the assignee is just as independent as if he owned the whole patent. This is a point that very few laymen appreciate. We frequently hear of an assignment of a one-half or one-quarter interest, whereas a tenth or a thousandth would be just as effective.

It often happens that the mere suggestion of a need for a certain improvement is the basis for its making and, while the work is done by the particular employe to whom the problem is submitted, in all probability there would be several others in the organization who, confronted with the same problem, would have arrived at the same solution.

As an illustration: A salesman visits a customer and the latter complains about a certain feature of the company's product; it is inaccessible; it is inefficient in operation; it soon gets out of adjustment, or has some other fault. The salesman reports the matter to the company, the engineering department is set to work on a new design and the improved device is made and tested until found to be satisfactory.

The customer, the salesman, the engineer, the resources and past experience of the company all enter into the making of that particular improvement, and it is difficult to determine which of these factors is entitled to the greatest credit. It is certain, however, that if the company wishes to secure protection for the improvement, it must get a patent for it and the application for the patent must be made in the name of some individual since under our laws a company cannot apply for a patent in its own name. As the application must be made in the name of the inventor of the improvement, the company can justly ask him to assign the improvement and the patent application to it for a nominal consideration, and in so doing the inventor should not feel that he is giving something to the company, but, rather that he is carrying out a necessary formality that the company may get the full benefit of the service he is employed to render.

While the company's moral right to the possession of patent rights for the improvements made by its employes in the course of their regular duties is clear, the legal title to the improvements must be established by an assignment. It is now customary to have the engineers and other confidential employes make an agreement to assign patent applications to the company. This is not because of any lack of confidence in the integrity of the employes but is merely a matter of good business policy which has for its object the full protection of the company's interests.

Engineers and other classes of employes frequently make patentable inventions outside the scope of their employment and the employer cannot justly lay claim to these in the absence of a contract with the employes covering this matter.

Designing engineers and production experts are usually relied upon by a manufacturer to make the necessary improvements in products and methods of production and, that there may be a clear understanding on the question of patents, it is advisable that there be a written contract in regard to patents defining the actual obligations of the employe. With such a contract the employe is free to do independent work outside of his employment,

and if in this work he makes an invention of value he is free to do what he pleases with it.

I have heard of men who have absolutely refused to execute a patent agreement, but this is clearly a very narrow attitude of mind because after such a refusal an employer would naturally be reluctant to place a man in a position of responsibility where he might take advantage of confidential information for his own benefit and to the detriment of the company. It would create a lack of confidence in the employe's integrity.

The owner of a patent may grant shop rights or licenses under his monopoly on such terms and conditions as he sees fit to impose or he may grant the right to practice his invention in a certain territory. Since the patent owner has a legal monopoly, he is privileged to fix the prices at which his licensees shall sell the invention and he may stipulate in his license that they shall not sell at prices lower than his in case he also manufactures the invention.

You have no doubt read at least the headlines of decisions in anti-trust cases when large industrial or commercial organizations have fixed prices. The courts always recognize the right to do that in the case of a patented invention because a patent is a monopoly created by the law.

The automobile industry has in its development been confronted with several very important patents, among which may be mentioned the Selden, Dyer and Kardo patents, but at the present time, nearly all patents that are being issued in relation to automobiles are for details which are largely in the nature of improvements and, generally speaking, unessential.

Most of the members of the National Automobile Chamber of Commerce have entered into a cross-licensing agreement whereby each party to the agreement is entitled to use the patented inventions of the other parties. So far as I am aware, there are at the present time no basic patent rights that threaten to disturb the industry. Some of the manufacturers have not agreed to this cross-licensing. Probably this is a wise and just move from their point of view, but I think the general effect of the agreement will be to do away with the chances of litigation.

The National Automobile Chamber of Commerce has for many years been collecting information in regard to the details of automobile construction, and this information has been filed and indexed so as to be available to the members of the Chamber as needed. The effect of this has been to stabilize the industry by protecting it from the unjust claims of owners of patents, and the work is in line with that of others which has for its object such improvement in our patent laws as to insure the issuance of valid patents only. Recently the Engineering Council of the Council of National Defense adopted resolutions favoring the revision of our patent laws to insure the issuance of valid patents and so stabilize the patent system as to make it a greater agency for constructive work in industry. In due course these resolutions will be presented to the engineering societies for consideration.

Increased Patent Office Facilities Needed

One of the things that should be done is to increase the facilities of the Patent Office. There is an active movement to present the matter to Congress in such a way that proper measures will be adopted. The Patent Office has up to the present time earned something like $7,000,000 which is lying in the treasury unexpended; and yet the examiners and other employes, most of whom are technical graduates, are very much underpaid and Congress has thus far refused to make adequate appropriations for increases in salary, notwithstanding the fact that the Patent Office fees amount annually to more than the cost of running the office. On the other hand numerous other branches of the Government that are simply an expense get increased appropriations annually and are in a flourishing condition. The Patent Office is a branch of the Department of the Interior and this handicaps it to a certain extent because Congress does not pass upon its needs as a separate item but includes it in the appropriation for the whole Department of the Interior. The heads of the various bureaus apportion these moneys and if the Pension Office has need of $200,000 more this year, the Patent Office will have to get on with that much less. The two bureaus are in no way connected, and the work of the Patent Office in which you are all more or less interested is in that way impaired.

The facilities of the Patent Office are utterly inadequate to handle properly the large number of applications that are filed annually. In recent years these applications have numbered from 60,000 to 70,000 annually and the pressure brought to bear upon the examiners in handling this mass of work has resulted in the issuance of numerous invalid patents. These patents are a menace to the industries to which they relate. When a patent is issued it gives the patentee the right to go into court and sue anybody he pleases. Of course, he has got to have a fairly good case or his suit will not last long, but you can see that a wholly invalid patent in the hands of large moneyed interests might be used against small concerns or individuals in a way that would be much to their detriment and wholly unjust. It is to the interest of the industries in general to have only valid patents issued. To accomplish this it will be necessary for Congress to greatly increase the appropriations for the Patent Office, so that men of as high or higher grade can be secured and retained in the examining force and be able to devote as much time as is necessary to each application. It is also desirable that a single Court of Appeals for patent cases be established so that there will be a line of uniform decisions to be recognized by all courts. At present conflicting decisions are frequently made in different jurisdictions with reference to the same patent, which is held to be valid in one and invalid in another.

The patent system is so closely allied with the industries of the country that the latter should become active in the work of improving the system and placing it on a firm foundation. Engineers are vitally concerned with patents but seem heretofore to have looked upon them as the business of the lawyer. The engineer is now taking greater interest in the subject and a large percentage of the patent lawyers today are engineers. The work of the patent lawyer is to a large extent engineering, and I believe that every engineer should know the fundamentals of our patent laws, just as every good business man knows the fundamentals of business laws.

The Discussion

A Member:—What is the Dyer patent referred to?

Mr. Kent:—The Dyer patents relate to sliding transmission. I do not know just what disposition was made of them.

Milton Tibbetts:—They are to some extent handled by the National Automobile Chamber of Commerce, in that it has a certain number of licenses that it can grant to its members. Whether all those licenses have been taken up I do not know.

A MEMBER:—Just what is the meaning of the phrase "more than 2 yr. prior"?

MR. KENT:—If an invention has been on the market or on public sale for more than 2 yr. before you file your application, under the patent laws you cannot get a valid patent. Even if granted, it would be invalid. They are often granted, because the Patent Office Examiners do not have information on the particular subject. An individual might make an invention and a company take up the manufacture of it and carry it on for several years without the knowledge of anybody in the Patent Office. An application for a patent on that invention might be filed, but if a patent were issued it would be invalid. If the Patent Office knew about the public use of the invention for several years the application would be denied.

A MEMBER:—I would like to ask how important the specification is as distinguished from the claims.

MR. KENT:—The specification should be sufficiently accurate to be a full disclosure of the invention, so that one skilled in the art could, from the description and the prior knowledge he is supposed to have, practice the invention. Sometimes, through rather indifferent preparation or lack of technical knowledge on the part of the attorney, the specification is so inadequate that it renders the whole patent invalid. However, the courts would be rather reluctant to declare a patent invalid on that ground unless the inadequacy of the specification was well established, because they usually give the inventor the benefit of the doubt.

A MEMBER:—If B conceives a patentable idea and applies for a patent, can A, who has represented the same idea on a blue print, interfere with his rights?

MR. KENT:—That takes us well into the question of priority of invention and involves questions of diligence. Sometimes a man will be conceded by the Patent Office to have invented first, but he will have neglected either to practice the invention or to file an application for it. In the meantime another man, wholly independently, presents an application for the same invention or starts to practice it. If the first man has abandoned his invention or has been sleeping on his rights, the other through diligence has become entitled to the patent.

A MEMBER:—Are we to infer that proved priority of conception could cancel a patent that has been given?

MR. KENT:—No. That brings in the same question, as to whether the prior inventor has been sleeping on his rights. It is a question not only of the period of time that elapses, but of what has been done with the invention. Of course, if the first inventor practiced his invention for more than 2 yr. before the second man filed, that practice would render the patent invalid.

A MEMBER:—Suppose he had practiced not for 2 yr. but for possibly 6 months or a year before the patent was applied for and made use of the material covered by the patent in the period before the patent was applied for by the other party?

MR. KENT:—In a situation like that, if the patent had not been issued more than 2 yr., so as to be a publication or a public use against the first man, he might file an application in the Patent Office and ask for an interference. For instance, suppose a man makes an invention on the first of January and proceeds to practice it. On the first of July another man conceives the same invention and immediately files an application for a patent to cover it. His patent will come out, say, the first of the following January. The first man sees the patent soon after it is issued. Under those conditions he would have the right to file an application in the Patent Office in his own name and ask for an interference. On that basis of fact the Patent Office would award him the patent as against the patentee and would publish the fact that such and such claims or perhaps all the claims of the patent had been awarded to another inventor.

A MEMBER:—The patent I have in mind was secured on an article using a certain material. Another organization obtained a patent on a material that was used in the construction of a different article and supplied licenses on it to other organizations. The first company's article contained the material covered by the other company's patent, yet the material had not been patented. The party making the article containing it had not filed an application.

MR. KENT:—The time element is a very important factor there. It is always important in patent matters anyway, and it is advisable to file applications for patents without delay. There are various technical rights accruing to the first man to file, especially if he gets into an interference.

A MEMBER:—What means, if any, can be resorted to to prolong the life of a patent? What protection has a patent after the 17-yr. period has expired?

MR. KENT:—There are practically no means for prolonging the life of any particular patent. The patent runs for 17 yr. from its date of issue and then expires, and there is no way of getting an extension except by special act of Congress. I believe no such act has ever been put through. An expired patent has no protection and is no protection. It is really a contract between the patentee and the Government or the public. If the inventor will disclose his invention to the public, the Government will give him the exclusive right to it for a period of 17 yr. At the end of that period the invention becomes public property. You see that by giving an individual exclusive rights in an invention for a long period the public has paid the price for using it, and therefore the inventor is not entitled under our law to any further protection. As a practical matter, however, a somewhat basic or pioneer patent may be issued, run its 17 yr., and expire, but in this time other patents may be taken out for improvements, so far superior, commercially, that the privilege of practicing under the old patent does not amount to anything. In a situation like that the monopoly from a practical point of view would continue because of the patents on improvements. That very situation prevailed in the telephone monopoly. After the original Bell patent expired, the Berliner patent, which was owned by the American Bell Telephone Co. and covered improvements, continued the monopoly for several years.

A MEMBER:—With regard to foreign patents, is the filing of an application for a patent in this country a protection in other countries? Must immediate application be made abroad, in Canada or other countries?

MR. KENT:—Of course, each country has its own laws as to conditions under which inventions are patentable; some countries provide that after publication anywhere of the invention or after practice anywhere, a patent will not be granted. On the other hand, the United States and most of the foreign countries have a convention under which the rights of an inventor to file an application are preserved for the period of 1 yr. That is, by filing an application in the United States, the inventor would, under this convention, have a right to file in any of the foreign countries that are parties to the convention, provided he made application within 1 yr. of the time he filed here and irrespective of whether he may have done something here or in any other country that would render it impossible for him to get a patent there. The Patent

Office will furnish information as to what countries are in this convention.

A MEMBER:—Do you happen to know if Canada is one of them?

MR. KENT:—It is not.

A MEMBER:—Suppose a company makes a certain class of machinery and you are interested in an improvement on that machinery. What is the best way to get a list of the patents covering that company's machinery? Could you get such a list from the Patent Office or write to the company?

MR. KENT:—The best way would be to have an attorney look it up. It is a simple matter, if you know the name of the inventor or inventors of the machinery made by the company. The patents might be issued to the company. Also the indexes of the patents would show the name of the company and give you the numbers of the patents. You could not get information in that way, however, as to the patents that are assigned to the company after they are issued. Almost any company would give you such a list; in fact would be practically compelled to do so if you ask for it because if it concealed a patent from you it would come pretty close to giving you an implied license to go ahead notwithstanding the patent. There is a nice question involved, and nothing definite can be stated on it, but I do not think a reputable concern would conceal a patent on certain features if asked for it.

A MEMBER:—The question asked about prolonging the life of a patent was possibly meant to cover the practice of keeping a patent in the office by successive amendments, thus putting off the date of issue.

MR. KENT:—I interpreted the question to mean prolonging a patent after its issue. Of course, since the patent runs for 17 yr. from the date of its issue, the longer you delay the date of issue the later will be the date of expiration. That is very often done.

A MEMBER:—Is there any way of having an assignment recognized, if it is not recorded in Washington. Has it any standing?

MR. KENT:—It has standing with those who know about it. Anybody who knows about it is bound to recognize it. The recording of the assignment in Washington is legal notice to everybody that the patent has been assigned.

A MEMBER:—Did I understand correctly that the holding of any fractional part of a patent entitles one to equal rights for production or disposal of that patent?

MR. KENT:—Yes, provided there is no special contract by which your right is tied up with the remaining rights. If you are assigned outright without any conditions you can proceed without considering the others. It is just like splitting the patent into two parts. Each owner can go his own way and ignore the other.

A MEMBER:—I understand that the Patent Office does not annul a patent after it is once issued. What is done to annul the first patent issued after winning out on a case of interference?

MR. KENT:—The first patent can be ignored. There is no need of having it annulled, although it might be by special court proceedings. The Patent Office has no authority to annul a patent after it is once issued.

A MEMBER:—That court proceeding would have to be in all districts to hold good over the entire country?

MR. KENT:—I do not think so. If a patent were ordered annulled by a court of competent jurisdiction, that would settle it. A man who lost his patent through adverse interference proceedings would not continue to use it.

A MEMBER:—I would like to inquire if a transfer of a patent right can be made by a bill of sale?

MR. KENT:—That can be done. A patent can go the same as any other personal property, but to make the transfer lasting, the bill of sale should be recorded in the Patent Office. Ordinarily people do not wish to record a document like that because it usually contains information that the average individual does not wish to have published, and a document that is recorded in the Patent Office becomes a public record to which anybody has access. It is customary under such circumstances to make a separate assignment of the patent. It is just a mere formal assignment that is recorded in the Patent Office. It is quite common to sell a business and stipulate in the bill of sale that the patents, trademarks and such property pass with the other property transferred by the bill. But as I have said, it is customary to make a separate assignment of the patents for the purpose of recording it in the Patent Office.

A MEMBER:—How much protection does a man have under a patent applied for?

MR. KENT:—He has his filing date, which shows when he filed his application with the Patent Office. He has nothing that he can go into court with or that he can assert against infringement. He has simply recorded his right to the patent, if he secures it. The words "Patent Applied For," shown on the article, may serve to keep people out of that particular line, because they may fear that when the patent came out they will be stopped.

A MEMBER:—Would that prevent an interference claim, if the date of the patent applied for was ahead of any other application?

MR. KENT:—No, it would not, if there was another application pending in the Patent Office. There would be an interference, provided the invention was patentable. The Patent Office will not declare an interference between two applicants claiming the same invention until it has decided that the invention is patentable. The usual practice is that one of the applications must be in condition for allowance and then the claims which are made by both parties are suggested to them. One party would receive a letter from the Patent Office quoting claims which have been deemed to be allowable in another application. A certain number of days is allowed for him to incorporate these claims in his application. If he does not make them within that time, he forfeits his rights to them.

A MEMBER:—Since court procedures are so enormously expensive in time and money would it not be advisable to follow the example of some other countries in the matter of patent reform and make it obligatory to lay out the patents previous to their being granted? In this way the burden of proof would not be at the expense of the inventor but would be carried by society at large.

MR. KENT:—That is a debatable question. There are some patent lawyers in this country who favor just that plan. It is practiced in some foreign countries, but to do anything like that would require complete revision of our patent laws and would put them on a basis entirely different from that now obtaining.

A MEMBER:—Is it possible in a few words to give us some idea as to what a patentable idea is, aside of course, from the point that it must be new? I have seen things marked "patented" so simple that it would not seem possible to get rights on them.

MR. KENT:—That is another debatable point; one that the inventor's attorney and the examiner often wrangle over for years. The examiner thinks the thing is not pat-

entable and the inventor thinks it is. It is largely a matter of judgment. I do not know how we are to determine which is right.

A MEMBER:—Assuming that a patent has been issued and recognized by agreement between two different countries, what effect would a declaration of war have upon its validity?

MR. KENT:—I do not think it would have any effect.

A MEMBER:—Assume a patent on some German invention to be granted and recognized in Germany. Would an American citizen have the right to practice the art in this country after war was declared?

MR. KENT:—Assuming that the German patent is taken out by a German subject and that he has an American patent, the validity of the latter has not been affected in any way. The President has issued a proclamation under authority of the Congress by which interested companies can get a license under the patent, proceeding, I think, through the Federal Trade Commission to do this. It does not affect the validity of the patent in any way, and it is my understanding that the license is for the period of the war only and under the present law the licensee who gets a license from the Federal Trade Commission would have to deal with the owner of the patent after peace is declared. There is rather a hazy atmosphere surrounding this matter. We are not all in agreement as to just what the situation will be when peace is declared.

AUTOMOTIVE FUEL COMMITTEE

A MEETING of much interest in connection with the automotive fuel problem was held in Chicago on Sept. 29. A report of the proceedings in detail is not available at the time of going to press with this issue of THE JOURNAL. The Automotive Fuel Committee is constituted as follows:

H. L. Horning, representing the Society of Automotive Engineers; Henry M. Crane, representing the Manufacturers' Aircraft Association; M. L. Heminway, general manager Motor and Accessory Manufacturers' Association; Henry R. Sutphen, National Association of Engine and Boat Manufacturers; T. C. Menges, representing the National Gas Engine Association; J. E. Pogue, Smithsonian Institute; E. W. Dean, Bureau of Mines, and H. C. Dickinson, Bureau of Standards; K. W. Zimmerschied, National Automobile Chamber of Commerce, and E. A. Johnson, National Implement and Vehicle Association.

The points included in the resolutions passed at the meeting in August of representatives of the American Petroleum Institute and of the automotive industry were considered, particularly with reference to the formulation of a definite list of the problems of the automotive industry relating to engine fuel and its use and the carrying on of research work in the laboratories of the automotive and oil industries. In connection with the former, the following are considered major problems: Vaporization of the present fuels which have a wide range of boiling points, and the chemical instability of the fuel.

The program of the Automotive Fuel Committee is to consider the fuel situation and promote research intended to aid in the problem of insuring an ample supply of fuel and the development of ways and means for its economical use in internal-combustion engines, with authority to confer and cooperate with accredited representatives of the petroleum industry to these ends. The committee is in communication with scientists conducting research work abroad on the rate of flame propagation of different proportions of mixtures of different fuels and combinations; the exact temperature of ignition of different fuel proportions and mixtures of fuels and the temperature of self-ignition of different fuel mixtures and combinations of fuels.

The Automotive Fuel Committee's first objective, which is apparently within striking distance, is the burning of present fuels and those of the next 3 years more efficiently. The S. A. E. Committee on Utilization of Present Automotive Fuels is preparing a report on more efficient utilization of present automotive fuels in existing and new designs of engines. This involves consideration of the initial, middle and end boiling points of the fuels now being produced for automotive use in great quantities. In turn it will be necessary to know what boiling points will be prevalent within the next 2 years. It is obvious that the more definite information the automotive industry can receive in this connection, the better it can design and construct its apparatus to meet essential needs. In other words, in the general sense, no apparatus can be designed without at least approximate knowledge of the fuels to be used with it.

The Measurement of Gages[1]

THE very large number of gages of various kinds necessitated by the vast output of munitions of war has caused many engineers to turn their attention to the manufacture of accurate gages, and some of these perhaps have had very little previous experience in working within a tolerance of 0.001 in., which is a common requirement, or of 0.0001 in., which is necessary for many master gages.

The production of accurate work is greatly facilitated if the maker is able to measure his own work in course of or after manufacture, and in my experience some makers have encountered considerable difficulty simply because they had no ready means of doing so. The present article, therefore, is intended to indicate the general methods of measuring the more difficult kinds of gages, and it is thought that such information may be useful to gage makers or gage testers.

The measurement of a plain plug or bar is a simple and straightforward matter, requiring only the use of an ordinary micrometer or measuring machine and the necessary reference disks or end bar standards. Similarly, plain rings or snap gages are directly measured by plugs, bars, internal micrometers or Johansson gages. Screw gages present a more difficult problem, and recently a great deal of attention has been given to them, but as an excellent pamphlet, containing full information on screw-gage measurement, is published by the British National Physical Laboratory, these gages will not be dealt with here. There remain three classes not yet dealt with generally; plate or form gages, the profiles of which are combinations of straight lines and curves, conical plugs, rings and disks, combinations of cones with cylinders and planes and castellation and position gages.

Commencing with the profile gages, it should at once be pointed out that all such gages made to close limits should be as flat as possible, should have their edges perfectly straight where intended to be so and perfectly square with the faces of the plate. Lack of attention to these points renders the absolute size of a gage difficult to determine and in some cases is serious enough alone to cause its rejection. When the edges of a gage can be machined or ground, the machine should produce practically straight and square edges, while smaller gages of complicated form, which have to be hand-finished, may have their edges trued up by the aid of simple lapping jigs.

When a maker has a large number of gages of one kind to produce, he will first make a master gage to which they will be fitted, and it is desirable that the checks should be made as accurately as possible, and also that the maker shall know that they are so before he completes the gages.

Profile Gages

Suppose, for instance, that a number of gages such as are shown in Fig. 1 are required, and that the tolerance allowed on all dimensions is + 0.001 in. The check gage required will be of the form shown in the lower portion, its dimensions being the nominal dimensions of the gage. The usual workshop method of measuring such a check consists in taking a micrometer measurement over the sharp corners and in measuring the angles of the ends by a bevel protractor. The measurement over sharp corners, however, is in general unsatisfactory, as the corners have a tendency to become rounded and so give a smaller reading than the true size. Again, angle measurements with an ordinary bevel protractor cannot be obtained with an accuracy closer than about 2 min., which is equivalent to 0.0006 in. on a length of 1 in., so that by such means the length of the shorter side of the check would be uncertain to twice that amount.

For these reasons the standard method of measuring such a check is either to stand it upright on a good surface plate or lay it flat on a plate with its shorter side firmly held against a straight-edge, as shown in Fig. 2. A pair of small cylinders of equal size are then placed in the angles formed by the gage and the plate, and a micrometer measurement a is made over the cylinders; two larger cylinders are then substituted for the small ones, and a second measurement b is made over them. From two or three such measurements along the sloping edges, the total angle and the widths at the top and bottom can be calculated, while the symmetry of the ends can be tested by a bevel gage, which should have a knife-edge blade. The cylinders used should be truly round and parallel and in pairs of equal size, one end being flat and square with the axis so that they will stand upright. Hoffmann bearing rollers, specially selected for roundness, have been found very useful for this purpose, but a set of hardened cylinders of suitable sizes is easily made.

It is sometimes necessary or more convenient to use cylinders of only one size on such a gage, but they are then packed up at various heights above the base, as shown in Fig. 3. The packing blocks should, of course, be exactly equal on the two sides of the gage. Johansson gages are well suited to this work, but any well-finished steel blocks of known sizes can be used. When setting up a gage in this way the smaller side should be placed in contact with the surface plate or straight-edge, so that the cylinders will set themselves into the angles under the pressure of the micrometer. If the gage were inverted the cylinders would tend to ride up the slopes. It is necessary, moreover, to hold the gage against the surface plate while measurements are being made to prevent it lifting under the wedging action of the rollers. If the gage is laid parallel with the surface plate while being measured, it should be packed up to a convenient height for handling the micrometer, and the faces of the latter may be supported at the same height. The measurements over the cylinders, if compared with the previously calculated values for a gage of the nominal size, will show at once whether the gage is within the tolerance allowed.

Gages with Curved Edges or Holes

This method is equally applicable to gages having curved edges such as that shown in Fig. 4, but in this case the symmetry of the figure about its base edge has to be measured also. In some cases direct micrometer measurements of the dimensions f and g can be taken across the cylinders, and these dimensions will be equal if the symmetry is good. If this plan is not possible, a square is fixed to the straight-edge, as at h, and at a definite distance from the lower cylinder i. The horizontal distance j from the upper cylinder k to the edge of the square-blade is then measured by Johansson gages, or else the width l over the cylinder, and the other edge of the blade is measured by a micrometer. The square may

[1]From an article, substantially in full, by E. A. Forward, which appeared in a recent issue of *The Engineer* (London).

be set by a block placed between the lower cylinder and the blade, but the square must be fixed and the block removed afterward for the insertion of the height packing of cylinder *k*. The same operation is then performed at the opposite side of the gage, and if the symmetry is correct the distances to the upper cylinders will be equal. This general method is applicable to many different forms which need not be further specified.

and is packed out at different distances from the square-blade. At each of these positions a micrometer measurement *p* is made over the top of the cylinder and the stock of the square, which, of course, should be of uniform width. This operation is repeated for the other slope and the measurements compared with the calculated values. The angle and symmetry of the lower slopes can be tested in this right-angle setting if the gage be set at a

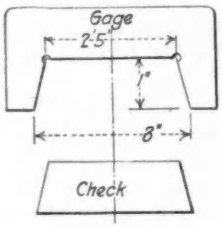

Fig.1

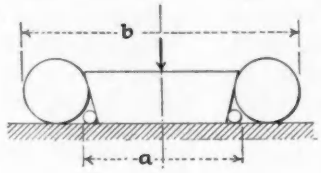

Fig.2.

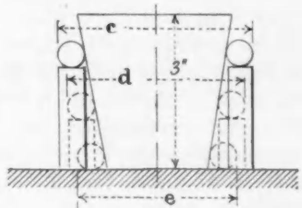

Fig.3

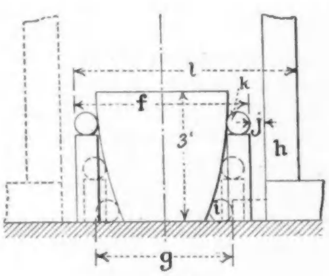

Fig.4

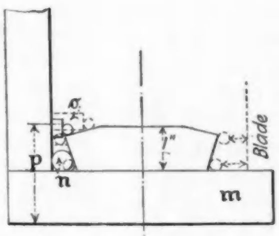

Fig.5.

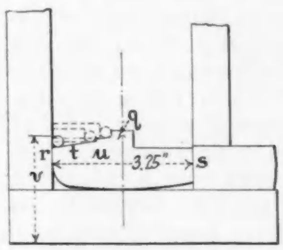

Fig.6.

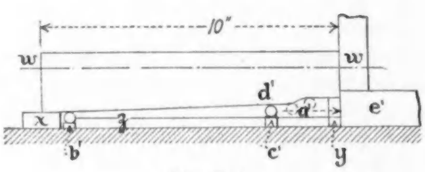

Fig.7.

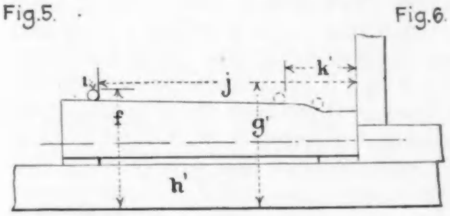

Fig.8.

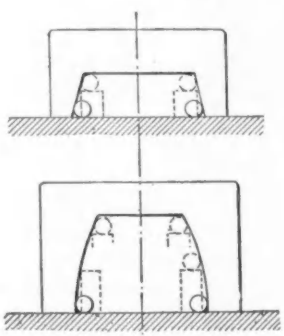
Fig.9.

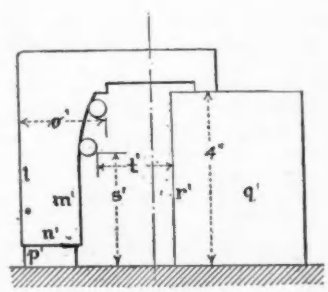

Fig.10.

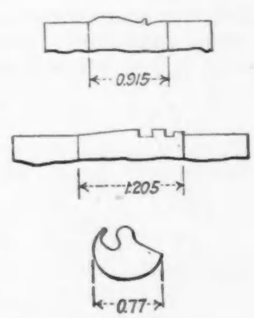

Fig.11.

Various Forms of Gages and Some of the Methods Employed to Check the Accuracy of Their Dimensions

Another type of gage consists of a hole with an outline such as that shown in Fig. 5, and the check for this may be a solid piece of the same form made to the smallest dimensions of the gage. The width of the lower tapered portion will be dealt with as before, but the upper slopes are best treated as follows: The gage is placed horizontally on a surface plate with its base resting against the stock of a thick bladed square *m*, the blade of which is in contact with a cylinder *n*, touching the lower sloping edge of the gage. Another cylinder *o* rests on the upper slope

convenient distance from the square-blade and the distances from the cylinder to the blade be measured at different heights above the base, as indicated on the right of Fig. 5. The difference between the heights when divided by the difference between the upper and lower distances gives the tangent of the slope. It is necessary with this arrangement that the gage should be held firmly in the square both vertically and horizontally during the measurement and that the square should be secured to the surface plate.

A more awkward gage of the same type is shown in Fig. 6; here there are only the three short straight parts *q*, *r* and *s* to set up by, the base being composed of two circular arcs. The gage is held in the angle of a large square, as in the previous case, and a smaller square is clamped up against the right end as shown. If the ends *r* and *s* are parallel with the gage centre line, the gage will set itself with its axis square with the base. The slopes *t* and *u* are measured by resting a roller on them at different distances from the square-blade and taking a micrometer measurement such as *v* over the roller and the square-stock. The symmetry of the center piece *q* can be conveniently tested at the same time by fitting Johansson gages into the gaps on each side of it. The curved base is tested by inverting the gage in the same setting and performing the same operation along the curve from both ends.

Another form of gage, Fig. 7, is a narrow plate having one long formed edge which consists of two straight parts, at different angles with the ends of the plate, joined by an intermediate curved part. Here the back edge is of no importance, but the dimensions of the gage are given from a center line *w-w*. If in making the gage this back edge has been worked truly straight and parallel with the center line, and the smaller end made square with it, then the gage can be laid with the small end against a straight-edge and the widths measured from the back edge over a cylinder placed at different points along the profile. Generally, however, this back edge is left rough or insufficiently straight, so that a different method must be adopted. The gage is laid on the surface plate at a convenient distance from a straight-edge and with its smaller end against a square. Approximately correct packing pieces *x* and *y* are placed under its ends, the gage is clamped down and the long slope is measured by finding the coordinate distances *z*, *a'*, *b'* and *c'* of a cylinder *d'* from the straight-edge and square *e'* in two positions near the ends of the slope with Johansson gages. The slope is then corrected, if necessary, by adjusting the packing piece *x*, and the remainder of the profile is coordinated in the same way, the measurements being compared with the nominal calculated values.

An alternative, but less convenient, method is to invert the gage and take micrometer measurements, *f'*, *g'*, etc., over the back of the straight-edge *h'* and a cylinder *i'* resting on the formed edge of the gage at distances *j'*, *k'*, etc., from the square. This method is shown in Fig. 8.

Internal Profile Gages

So far external profile gages have been dealt with, but in some cases the master gage will be a space bounded by formed edges such as those shown in Fig. 9. In these cases the same general cylinder method is used, the gage being placed on a straight-edge or surface plate and the distances between the cylinders measured most conveniently by Johansson gages. The cylinders are packed up from the straight-edge as before by Johansson gages or special distance blocks.

Another form of gage is shown in Fig. 10. If its edges *l'* and *m'* are parallel to one another and square with the base edge *n'*, the curved edge can be measured by a cylinder and micrometer measurements *o'* over the edge *l'*. If, however, these edges are not true, then suitable packing pieces *p'* and *q'* have to be introduced to bring the edge *m'* square with the straight-edge. The edge *r'* of the larger block *q'* is itself square with its base, so that cylinder coordinates *s'* and *t'* can be taken along the outline of the gage.

There are numerous small profile gages of which some or all the elements are not directly measurable mechanically, and for them the optical projection method developed at the British National Physical Laboratory has proved of immense service. In this method a lantern projects a magnified and undistorted image of the gage on a screen, and the image is directly compared with an accurate drawing of the gage which is pinned on the screen beside it. Fine adjustments are provided for setting the drawing up to the image, and, with the magnification of fifty usually adopted, 0.05 in. on the screen represents 0.001 in. of metal on the gage, so that errors of less than this amount are easily seen. This apparatus is of great value as an adjunct to a workshop dealing with this class of gage, as it greatly facilitates their manufacture. It is essential for projection that all the edges of the gage should be quite square with the faces of the plate or they will not come into focus together; it is desirable also that the plate should be not more than 0.125 in. thick. Some typical examples are given in Fig. 11, and it may be mentioned that small radii on or in corners of gages are very effectively dealt with by projection.

High-Speed Internal-Combustion Engines[1]

IN the following paper I propose to examine and set out some of the features of high-speed engine design, and to indicate some of the points upon which the designers of these engines have concentrated their attention. In the first place, most of these smaller high-speed engines are designed to run on gasoline, and it is sometimes argued that the conditions under which they operate are totally different from those that apply to the larger and heavier types of internal-combustion engines. This is true, but to a limited extent only, for, generally speaking, what applies to a gasoline engine will with certain reservations apply equally to a gas or Diesel engine, while, so far as mechanical considerations are concerned, the problems to be faced are practically identical in either case.

The design of internal-combustion engines in England has in the last 20 yr. proceeded along two widely different lines, directed by two separate schools. On the one hand we have the designers of what may be termed the slow-speed type of engine who have consistently had to compete with and have based their designs upon steam-engine practice, and on the other hand we have the designers of small high-speed engines who have appeared with the advent of the motor car. The latter have created a school of thought of their own and have developed along lines which are distinctly enterprising. Between these two separate schools, prior to the outbreak of war, there had been practically no interchange of ideas or experience. Each was as ignorant of what the other was doing or aiming at as though they had been working at totally different problems.

If we review the progress of both schools impartially, we find that the slow-speed school has consistently designed its engines upon sound thermodynamic lines and has been influenced very largely by such able and distinguished men as Sir Dugald Clerk, Professor Hopkinson and many others. They have, however, exhibited a decided lack of enterprise or initiative in dealing with the mechanical features. On the other hand, we find that until quite recently, at all events, the designers of the high-speed school have shown an utter indifference to the laws of thermodynamics, their ignorance of which has been, for the most part, profound, but they have shown a creditable degree of enterprise and imagination when dealing with the mechanical problems. It is surprising that in spite of the fact that their knowledge of the thermodynamic laws might in most cases be summed up as consisting of a mass of vague superstitions, they have nevertheless succeeded, through a laborious process of trial and error, in producing engines whose efficiency is now comparable with those of the low-speed school.

As an illustration of the complete lack of intercommunication between the two schools, the case of the 40-hp. Mercedes car may be cited. This car when it first appeared made something of a sensation because its engine was really reasonably silent, at least by comparison with other engines of that date. On careful investigation, it was found that it embodied an astounding and novel feature, namely, mechanically operated inlet valves, and yet such valves had been used as a matter of course on nearly every gas engine for at least 30 yr. Again, it was not until very recently, in fact, since the outbreak of war, that the designer of the heavier slow-speed type of engine really began to awake to the great importance of cutting down the weight of the reciprocating and rotating parts, although light moving parts have for years formed the very essence of high-speed engine design.

Development of Light Engines

During the war the development of light high-speed engines has progressed with very remarkable rapidity and has received a very great impetus from the fact that a large number of well-trained and scientific men have devoted their attention to it, and taking advantage of the many excellent mechanical features already to be found in these designs, have also directed their development along sound scientific lines.

In answer to any imputation as to their lack of theoretical knowledge, the designers of high-speed gasoline engines almost invariably used to reply that, besides being able to run at much higher piston speeds, their engines could use higher mean pressures and showed a thermal efficiency equal to, and in some cases relatively higher than, the average gas engine. This retort was generally true, and before proceeding further it will be well to devote a short time to comparing the advantages and disadvantages of town gas and gasoline as fuel. In the first place, other things being equal, the power output of any internal-combustion engine depends upon the weight of oxygen that can be taken into the cylinder and burned in a unit time. Here gasoline scores a very decided advantage for three reasons:

(1) To consume the whole of the oxygen present in the cylinder, the volume of gasoline required is only slightly over 2 per cent, while that of town gas is nearly 17 per cent, consequently the volume of oxygen dealt with in the case of gasoline is about 15 per cent greater

(2) Owing to the latent heat of evaporation of gasoline, the temperature of the working fluid is reduced both before and during its entry to the cylinder; hence a slightly greater weight is taken in for a given volume

(3) After combustion the specific volume of the working fluid consisting of an air-gasoline mixture is increased by about 4 to 5 per cent, while that of an air-gas mixture is reduced by about 3 per cent

On these three grounds alone gasoline scores heavily, for not only does the fuel itself displace less oxygen, but it also withdraws heat from the charge and thereby increases its weight, while, finally, the actual volume of the charge after combustion is greater than before. On the other hand, gasoline labors under two serious disadvantages:

(1) Owing to its very limited range of inflammability it is not possible, as with town gas, to work with a weak mixture. In fact, the mixture giving complete combustion is almost identical with that giving maximum economy, for if the mixture be weakened to any appreciable extent below that required to give complete combustion, ignition is seriously delayed and continues throughout the expansion stroke. As a result of this peculiarity, it is not possible by ordinary means to reduce the flame temperature, and since the efficiency of any engine, relative to the air-cycle efficiency, is de-

[1]From a paper by H. R. Ricardo read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne.

pendent upon flame temperature, owing both to direct loss of heat and to the change in specific heat at high temperature, it follows that from this point of view a gasoline engine can operate only under the most disadvantageous conditions

(2) Owing to its low ignition temperature and to the high proportion of hydrogen present in the fuel, it is not possible to work with so high a combustion pressure. In practice the limiting compression ratio that can be used for gasoline is about 5 to 1, depending, of course, upon a number of subsidiary conditions. This gives an air-cycle efficiency of 47.5 per cent. With town gas, on the other hand, it is possible to use a compression ratio as high as 6.25 to 1, giving an air-cycle efficiency of 52 per cent

These last two conditions operate in favor of gas more particularly as regards fuel efficiency.

The Diesel Engine

We will consider next the case of the Diesel engine. This engine has the following advantages in its favor:

(1) No fuel is taken into the cylinder until after the end of compression, hence no oxygen is displaced and the greatest possible volume is taken in

(2) The combustion of crude oil and air also results in an increase in the specific volume, as in the case of gasoline

(3) Additional air, compressed separately, is nearly always admitted to the cylinder along with the fuel. The increase in mean pressure due to the presence of this additional air is invariably credited to the indicated power of the engine. This gives the Diesel engine an apparent indicated power which is altogether illusive. In common justice, the indicated horsepower absorbed by the compressor should be deducted from that developed in the cylinder, before any comparison is made between it and other internal-combustion engines

There are many variables connected with the Diesel cycle. In the first place the air-cycle efficiency itself varies with the flame temperature. Again, the proportion of air admitted along with the fuel has a powerful influence on both the mean pressure and efficiency, and that proportion is a variable quantity. Third, the highest mean pressure attainable is governed not so much by consideration as to the quantity of oxygen present in the cylinder as by the quantity that can be brought into contact with the particles of fuel and burnt in the short time available.

From the figures given it is clear that while with gasoline it is possible to obtain an indicated mean pressure of 146 lb. per sq. in. under extreme conditions, or 136 lb. per sq. in. under economical conditions, with town gas it is not possible to obtain a higher mean pressure than about 110 lb. per sq. in. even when working with the richest possible mixture. On the other hand, while with gasoline it is not possible under any normal circumstances to obtain an indicated thermal efficiency of more than 33 per cent, with town gas it is possible to obtain an efficiency as high as 37.5 per cent when working with a weak mixture and a low flame temperature. The best modern gasoline engines, such as those employed for aircraft work, do actually realize an indicated thermal efficiency of over 32 per cent, while gas engines have occasionally given an efficiency as high as 37 per cent, showing that in both cases there is not much scope for improvement so long as the usual cycle is adhered to. It is obvious, however, that the thermal efficiency of either type of engine, and more particularly of the gasoline engine, could be greatly increased by working with a lower flame temperature. Theoretically the efficiency rises as the flame temperature is reduced until at the point of no heat supply the efficiency will be equal to the air cycle, but the power will be nil.

Owing to the very limited range of inflammability of gasoline and air mixtures it is not possible by ordinary means to work with a weak mixture and hence at a lower flame temperature; this, of course, applies only so long as the working fluid is homogeneous. It is interesting to consider what would happen if into a cylinder full of air there were inserted a paper bag containing a small charge of an air-gasoline mixture of normal density and that at the end of the compression stroke this mixture were ignited and the bag burst so that its contents, already fully aflame, were discharged into the large excess of air present. Under these circumstances the effect would be equivalent to working with an extremely weak mixture, the mean flame temperature would be very low and the efficiency very high. Some such condition as this can be reproduced in a practical form by means of stratification. When running under these conditions the indicated thermal efficiency was not less than 38 per cent with a mean pressure of 23 lb. per sq. in. In a Diesel engine, of course, the conditions are somewhat similar, and the high efficiency of this engine is largely due to its low flame temperature under reduced loads.

Gas and Gasoline Compared as Fuels

While comparing the two fuels, gas and gasoline, there are two other points which need consideration. Gasoline is a liquid, and before it can be used in the engine it must be vaporized or at least finely pulverized. This entails a certain loss, though a very small one, and it also imposes certain restrictions in the design, especially that of the piping lines which must be carried out in such a manner that the pulverized and partially vaporized particles of gasoline are kept in rapid and, as far as possible, continuous motion, to prevent them from precipitating on the walls of the pipework. The other peculiarity of gasoline is its readiness to detonate because of its chemical instability and of the large proportion of hydrogen present. Such detonation is generally referred to as "pinking," and often, but quite erroneously, as pre-ignition. Pre-ignition means, of course, self-ignition of the fuel before the end of the compression stroke. Detonation, on the other hand, is merely extremely rapid burning, so rapid indeed as to cause local rises of pressure which spring the walls of the cylinder and cause them to vibrate as though they had been struck by a hammer. What actually occurs appears to be this: A portion of the working fluid in the neighborhood of the spark-plugs is ignited and proceeds to burn in the usual manner, but so rapidly that it compresses the rest of the unburnt charge before it, until the heat of compression is such that the unburnt residue ignites spontaneously and suddenly throughout its whole bulk; in other words, flame propagation proceeds normally at first and then suddenly changes and becomes practically instantaneous. This tendency to detonate is very tiresome and it, of course, increases as the compression ratio is increased and the temperature and pressure of the working fluid are raised by compression. It is, as might be expected, dependent to a considerable extent upon the shape of the combustion chamber and the position of the igniter, and it also depends upon the density of the fuel; the denser the gasoline the greater the tendency to detonate, presumably because the heavier fractions are chemically less stable than the lighter ones. It becomes particularly troublesome when working with paraffine. Such detonation can be kept in check in several ways:

(1) By reducing the temperature and pressure of compression by the admission of water or other such means

(2) By increasing the proportion of carbon in the fuel by mixing it with hydrocarbons of the aromatic series, such as solvent naphtha, metaxylene or benzol

(3) By introducing inert gases, and preferably by adding gases containing carbon, such as carbon dioxide. In practice this can be accomplished by readmitting cooled exhaust gases, a method frequently adopted in the case of large gas engines using coke-oven gas, in which the proportion of hydrogen is large, and the same trouble arises

This tendency to detonate compels the use of a lower compression ratio than would otherwise be necessary, and is a serious handicap to the gasoline engine.

Mechanical Efficiency

In modern high-speed engines every effort is made to obtain the highest possible mechanical and volumetric efficiencies, and these efforts have met with such success that there are examples of very small engines running at piston speeds as high as 1800 ft. per min. in which the mechanical efficiency is over 90 per cent and the volumetric efficiency over 96 per cent, a result which the low-speed schools have seldom, if ever, been able to achieve even with their conventional piston speed of only 800 ft. per min. One of the chief problems which the high-speed engine school has dealt with in very thorough fashion, is that of eliminating the mechanical losses, and they have certainly reduced this to a fine art.

The mechanical losses of any internal-combustion engine may be divided conveniently into three groups:

(1) The losses due to bearing friction and the driving of such auxiliaries as the valve gear, oil-pumps, ignition, etc.

(2) Piston friction

(3) Fluid pumping losses

The last of these is not, strictly speaking, a mechanical loss at all, but it is customary and very convenient to include it under this head. It is usual to specify the mechanical losses in percentages of the indicated horsepower, but in my opinion it is preferable from many points of view, and particularly when the speed is a variable quantity, to classify them in terms of mean pressure per square inch of piston area, that is in terms of torque rather than power, so that they are directly comparable with the mean effective pressure. All the more so since it is now customary to measure the actual torque in terms of mean pressure per square inch of piston area. This is referred to as the brake mean pressure, i. e., the mean pressure corresponding to the brake horsepower of the engine.

Let us consider the losses included under the first heading. These, of course, are dependent to some extent upon the number of auxiliaries driven from the crankshaft, also upon the number of cylinders between which they are shared and, to a small extent, upon the weight of the flywheel. The torque equivalent of some of these auxiliaries is dependent upon the speed of rotation; of others, is independent of it. Numerous experiments have been made to ascertain the extent of the losses included under this heading, and as a result they have been found to range from 1.5 lb. per sq. in. mean pressure in the case of a modern six or twelve cylinder airplane engine up to over 3 lb. per sq. in. in the case of a heavy single-cylinder gas engine. As a general rule they may be taken as ranging from 2 to 2.6 lb. per sq. in. for an average high-speed engine and may for a 100-hp. six-cylinder engine be subdivided as shown.

	Lb.		Lb.
Bearings	0.75	to	1.00
Valve-gear	0.75	to	0.80
Magneto	0.05	to	0.10
Oil-pump	0.15	to	0.25
Water pump	0.30	to	0.50
Total	2.00	to	2.65

Piston friction is generally by far the largest item and is somewhat difficult to account for. In high-speed engines with an enclosed crankcase and forced lubrication the piston may be regarded as being practically oil-borne. Compared with the main bearings, however, the average loading is very much lighter and the rubbing velocity not so very much higher. At first sight, therefore, it would appear that the friction of the piston on the cylinder walls should not be greater than that of an equivalent area of bearing surface in other parts of the engine. That it is, in fact, enormously greater is probably to be accounted for in part by the fact that the motion of the piston is reciprocating and not continuous and in part by the fact that the lubricating oil is always more or less contaminated and carbonized, partly by the escape of a very small quantity of burning gases past the piston rings and partly by the exposure of the cylinder walls to the high temperature of combustion which tends to carbonize the film of the oil adhering to them. As a result of this contamination the viscosity of the oil is increased enormously, and therefore its resistance to shear also. A very large number of experiments have been carried out to determine both the cause and extent of piston friction in gas and gasoline engines. Briefly, it seems that the main causes are those stated above and that the extent is almost directly proportional to the average thrust on the cylinder walls and directly proportional to the rubbing velocity and the area of surface. It is found that when the area of surface is equal to π times the diameter, that is when the length and diameter are equal, the piston friction in terms of pounds per square inch can be found from the formula one-tenth of the sum of one-quarter the mean fluid pressure and two-thirds the mean inertia pressure, plus a constant which includes the average pressure on the cylinder walls due to the compression and which depends also to some extent upon the number and strength of the piston rings. This constant may vary from 1.5 to 4 lb. per sq. in., but generally averages about 2 lb. per sq. in.

This formula is, of course, purely empirical. It is open to criticism on the ground that the rubbing velocity is not taken into account, and that therefore the resistance of the oil film to shear is assumed to be constant. This is not the case, but the apparent error is largely corrected by taking very prominently into account the average component thrust due to the inertia pressure which varies as the square of the speed.

The extent of the fluid pumping losses depends very largely upon the form of pipework and upon the velocity through the piping and valves. Provided that the pipework, and particularly the intake pipe, is reasonably short, i. e., not more than eight diameters and that the internal diameter is not less than that of the valve port, also that the valve timing is more or less normal, the loss due to fluid pumping may be taken as dependent upon the velocity through the valve ports.

In the following table are given the mechanical losses of three actual engines, each of about 80 hp. per cylinder, with some details of the engines.

To make the tabulated figures truly comparative, no account is taken of the air compressor usually fitted to Diesel engines. The indicated mean pressure is taken as

Type of Engine	Diesel	Gas	Gasoline
Diameter of cylinder, in.	16	15	7.25
Stroke, in.	19	24	8.50
Normal speed, r.p.m.	250	220	1400
Piston speed, ft. per min.	790	800	1980
Weight of reciptocating mass, lb.	994	655	11.35
Mean gas velocity through valves, ft. per sec.	150	130	130
[2]Bearing friction	3.5	3.0	1.8
[2]Piston friction	11.8	7.8	7.2
[2]Fluid pumping loss	4.5	3.4	3.4
[2]Total losses	19.8	14.2	12.4
[2]Brake mean pressure	75.0	75.0	118.0
Mechanical efficiency, per cent	79.0	84.0	90.6

[2]Figures are lb. per sq. in. of piston area.

89 lb. per sq. in. in the gas engine and 130 lb. per sq. in. in the gasoline engine. It may be argued that while the mean pressure taken in the case of the gasoline engine is very nearly the maximum obtainable, that taken in the case of both the gas and Diesel engines, is well below the maximum, and that therefore the comparison is not a just one. The answer to this is that in both the gas and Diesel engines the cylinder bore is so large that it is not possible to work with higher mean pressures owing to the excessive heat gradient across the piston and through the walls of the combustion chamber. In the gasoline engine, however, with its small cylinder and thin walls it is possible to dispose of the heat, and that with the same or even a smaller temperature difference between the inside and outside of the cylinder walls and combustion head. Again, in the gasoline engine the mean pressure can be cut down only by throttling the charge, as already explained, and not by reducing the mixture strength.

TECHNICAL MEN FOR THE CONSULAR SERVICE

THE officials of the State Department have expressed the hope that a large number of technical men will take the coming consular examinations. The Department recognizes that the interests of the United States will be served best if technical men are made available through these examinations for vacancies at points where their training will be of special value. The department wants retired engineers and other technical men to take the consular examinations through which they can undoubtedly qualify for the best positions.

The consular examinations will be held in the late fall or early winter, but no definite date has been fixed as yet. The engineers who pass the examinations will be assigned to industrial centers of Europe or South America, requiring men of special training, such as they have either received at the colleges from which they were graduated or acquired in commercial life.

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The Horsepower of Resistance in Airplane Design[1]

By N. L. Lieberman[2] (*Member*)

Buffalo Section Paper

Illustrated with Charts and Photographs

A LARGE factor in the horsepower requirement, particularly at high speeds, is the wing resistance. As landing speed is the criterion for the wing area, two machines of the same weight may be equipped with wings of very different area, the larger area for the lower landing speed. Therefore at the same higher speed, these two machines would exhibit considerably different requirements in horsepower, even if the wing curve were not considered. The converse naturally holds. If two machines have the same wing area but differ in weight, the lighter machine will have the lower landing speed and slightly higher maximum speed.

Three general cases in machine variation present themselves.

CASE I

Scale Machine $A = n$ times scale of machine B (or the dimensions of linear A are n times the corresponding ones of B)

Weight $A =$ weight B

$\therefore$ Area $A = n^2$ area B

Lift $A = k\,A_a\,V^2_a = k\,n^2\,A_b\,V^2_a$

Lift $B = \qquad = k\quad A_b\,V^2_b$

$\therefore$ Lifts being constant since weight $A =$ weight B,

$k\,n^2\,A_b\,V^2_a = k\,A_b\,V^2_b$

or $V_b = n\,V_a$

The resistance or thrust required is

$$D_a = k_1 A_a V^2_a + k_1 A^1_a\,V^2_a = k_1 V^2_a\,(A_a + A^1_a) = k_1 V^2_a\,n^2\,(A_b + A^1_b)$$

$$D_b = k_1 A_b V^2_b + k_1 A^1_b\,V^2_b = k_1 V^2_b\,(A_b + A^1_b) = k\,V^2_a\,n^2\,(A_b + A^1_b)$$

$$\therefore D_a = D_b$$

Horsepower required

$$HP = \frac{88\,DV}{33{,}000} = \frac{D\,V}{375}$$

$$HP_a = \frac{D_a V_a}{375}$$

$$HP_b = \frac{D_b V_b}{375}$$

$$\therefore \frac{HP_a}{HP_b} = \frac{D_a V_a}{D_b V_b} = \frac{1}{n}$$

$$HP_b = n\,HP_a$$

CASE II

Scale $A =$ Scale B

Weight $A = m$ times Weight B

Proceeding as in Case I

Velocity $\quad V_a = \sqrt{m}\,V_b$

Thrust $\quad D_a = m\,D_b$

Horsepower required $HP_a = m\sqrt{m}\,HP_b$

CASE III

Scale $A = n$ times Scale B

Weight $A = m$ times Weight B

Proceeding as in Cases I and II

Velocity $\quad V_a = \dfrac{\sqrt{m}}{n}\,V_b$

Thrust $\quad D_a = m\,D_b$

Horsepower required $HP_a = \dfrac{m\sqrt{m}}{n}\,HP_b$

Applying the results of Case II we have the following results for the same altitude in horizontal flight if A is a 2400-lb. machine and B is a 2100-lb. machine:

$$V_a = \sqrt{1.14}\,V_b = 1.07\,V_b$$
$$D_a = 1.14\,D_b = 1.14\,D_b$$
$$HP_a = 1.14\sqrt{1.14}HP_b = 1.22\,HP_b$$

From records of the two machines the following figures are obtained: At an angle of 2 deg., the velocity of machine A is 80 m.p.h., the thrust is 440 lb. per sq. in., and the power required is 94 hp. For machine B at the same angle the corresponding figures are 75 m.p.h.; 380 lb. per sq. in. and 77 hp. Substituting in the formulas given above we obtain

$$V_a = 1.07 \times 75 = 80.2$$
$$D_a = 1.14 \times 380 = 435$$
$$HP_a = 1.22 \times 77 = 94$$

Most of the horsepower requirement curves show a characteristic minimum point, beyond which, at either greater or less velocity, the horsepower requirements are increased. The influence which controls this phenomenon is the horsepower consumption of the panels.

The total horsepower requirements are subject to variations in direct proportion to the (weight)$^{3/2}$ in inverse proportion to the size and dependent on the wing curve.

Distribution of Horsepower Consumption

There is no fixed ratio in accordance with which the total horsepower requirements can be resolved for the component parts of an airplane. The following, however, appears to be true for the four types studied:

(1) The percentage of total horsepower consumed by each component group is dependent on the type of group and machine

(2) The percentage of total horsepower consumed by each component group is generally independent of the weight of the machine

(3) The panels show a decrease in requirement with increasing speeds

(4) The remaining component groups show increasing requirements with increasing speed

(5) The panel percentage requirement increases in any given type for increases in weight, whereas the percentages of the remaining groups decrease

(6) The range of percentages of total horsepower requirements for the different groups, at increasing speeds, is of the following order:

[1] Concluded from the September issue of The Journal.

[2] Assistant engineering manager, department of education and sales promotion, Curtiss Aeroplane & Motor Corporation, Garden City, N. Y.

	Per Cent
Panels	80 to 25
Panel accessories	5 to 25
Landing gear	3 to 17
Tail units	2 to 15
Fuselage	10 to 45

A general statement of "parts resistance," or horsepower requirements, cannot logically be made without considering both type and velocity.

Burden Distribution

The preceding figures have given the actual percentages of total horsepower per group without regard to the weight of the group with respect to the machine. In Table 2 it will be noticed that the percentage of the total machine weight varies for each group, both for machines of the same type and for machines of different types. This variation may be due to construction, to loading of machine, or to both. A curve which will show the relative horsepower expense of each group for its weight the writer has called a "burden curve." Thus a part or group which constitutes a very small percentage by weight may be very expensive in horsepower consumption in proportion to its weight. This curve is obtained by plotting as ordinates the values obtained in dividing the "percentage horsepower consumption," of each group, at various speeds, by the percentage weight of the part or group, and as abscissas the speed in m.p.h. These curves show that

(1) The burden of the panels decreases with increasing speeds

(2) The burdens of the other groups increase with increasing speeds

(3) The panel accessories have generally the largest burden-figure of all groups

(4) The burden of the fuselage is practically constant for different speeds

(5) In any one type an increase in weight increases the burden of the panels and decreases the burden of the remaining groups

In interpreting "burden curves" the precaution should be borne in mind that these curves are functions of the percentage weight of a part besides the resistance. Thus, while the form of a group may be unchanged, and hence the aerodynamic property is unaltered and the horsepower requirement kept constant, the internal construction may be altered to reduce its weight. The weight percentage of the group thus decreases and the burden figure increases, the burden being equal to the quotient of the percentage of total horsepower required

TABLE 2 DATA ON WEIGHTS, SPEED AND PANEL AREAS OF AEROPLANES

Machine		Gross Weight, Lb.	Gross Panel Area, Sq. Ft.	Speed Range, Miles per Hr.		Parts, Percentage of Total Weight					Wing Curve No.
No.	Type			Low	High	Panels	Panel Accessories	Landing Gear	Fuselage	Tail	
3	2	2,100	352.0	50	95	14.35	4.87	3.43	75.0	2.41	Eiffel No. 36
4	2	2,400	352.0	50	95	12.55	4.30	3.00	78.1	2.11	Eiffel No. 36
5	3	2,750	416.0	55	125	11.50	2.07	5.45	78.8	2.16	R.A.F. No. 15
6	3	3,650	416.0	55	125	8.66	1.56	4.11	84.0	1.63	R.A.F. No. 15
7	4	3,650	505.0	55	105	11.40	2.74	4.60	79.6	1.67	R.A.F. No. 6
8	4	4,300	505.0	55	105	9.66	2.33	3.91	82.5	1.41	R.A.F. No. 6
1	1	1,800	246.0	55	125	10.30	2.78	5.00	79.8	2.00	R.A.F. No. 15
2	1	2,050	246.0	55	125	9.06	2.44	4.39	82.2	1.76	R.A.F. No. 15
9	2	2,100	280.0	50	110	9.33	3.10	4.56	80.2	2.52	R.A.F. No. 15

divided by the percentage of total weight. A high burden figure may thus be due to either a high resistance or a low weight. In either event it serves as an index to the relative horsepower expense of the groups and shows where improvement may be centered.

Flight at High Altitude

The general formula [6] obtained in the discussion on dynamic similitudes showed that the density of the medium affected the dynamic reaction

$$F = \rho_2 L V^2 \psi[\ldots.]$$

The density of the atmosphere decreases as the altitude increases. The weight of the machine remains practically constant with increases in altitude within the field of operation, hence if

$$\rho_o = \text{density at sea level and}$$
$$\rho_h = \text{density at altitude } h,$$
$$W = \rho_o k A V^2_o = \rho_h k A V^2_h$$

from which

$$V_h = V_o \sqrt{\frac{\rho_o}{\rho_h}}$$

that is, the velocity at altitude h increases in the proportion $\sqrt{\ (\rho_o/\rho_h)}$ over the velocity at sea level. Also

$$D_h = \rho_h k A V^2_h = \rho_h k A \left(\frac{\rho_o}{\rho_h}\right) V^2_o = \rho_o k A V^2_o = D_o$$

that is, the drifts and hence the thrusts remain constant at the respective velocities for any given altitude of the machine. Again,

$$HP_h = HP_o \sqrt{\frac{\rho_o}{\rho_h}}$$

or the horsepower requirements at altitude h increase in the proportion $\sqrt{\ (\rho_o/\rho_h)}$ over the horsepower requirements at sea level.

Recent engine tests conducted under reduced pressure to obtain the equivalent condition to altitude, showed a decrease in power in the engine proportional to $(\rho_h/\rho_o)^{1.1}$. The efficiencies of propellers at different altitudes by tests were found to be

$$\eta_h = \tfrac{1}{2}\left[1 + \sqrt{\frac{\rho_o}{\rho_h}}\right]\eta_o$$

The engine output or available thrust at altitude h is $P_h \times \eta_h$, therefore

$$P_h = \tfrac{1}{2}\left(\frac{\rho_h}{\rho_o}\right)^{1.1}\left[1 + \sqrt{\frac{\rho_o}{\rho_h}}\right]\eta_o P_o$$
$$= \tfrac{1}{2}\left[\left(\frac{\rho_h}{\rho_o}\right)^{1.1} + \left(\frac{\rho_h}{\rho_o}\right)^{0.6}\right]\eta_o P_o$$

The quantities P_o and P_h represent the engine horsepower, as indicated in power curves, while HP_o and HP_h represent the horsepower requirements for motion. Hence such value of ρ_h as makes HP_h equal to P_h, indicates the limit of climb or ceiling of the machine. Combining the foregoing "available horsepower" statement with $HP_h = HP_o \sqrt{\ (\rho_o/\rho_h)}$,

$$HP_o = 0.5\left[\left(\frac{\rho_h}{\rho_o}\right)^{1.1} + \left(\frac{\rho_h}{\rho_o}\right)^{1.1}\right]\eta_o P_o$$

which is an expression for the ceiling of a machine when the available power and required power at sea level are known.

Transatlantic Flights

Recently aeronautical activities have been centered on large flying boats as a means for crossing the Atlantic.

What follows, therefore, constitutes a study on the probable size of craft, fuel load and power equipment necessary to accomplish this trip, based on the data and performances of similar craft.

If η = efficiency of the propeller system
P_o = engine output in horsepower
n = number of engines

the available power equals $\eta n P_o$, which in flight equals the power required, or $VD/375$. Since $D = W/(L/D)_e$, where the subscript e denotes "effective,"

$$\text{Available power} = \eta n P_o = \frac{VW}{375}\left(\frac{D}{L}\right)_e$$

By definition, the total weight is

$$W = nM + L_a + 160p + 6.15\lambda \quad \text{where}$$

nM = weight of n engines
L_a = weight of airplane
$160p$ = weight of crew numbering p
6.15λ = weight of λ gallon of fuel

If the engine consumption in gasoline and oil be γ lb. per b.hp., for n engines of P_o hp. each the consumption per hour will be $\gamma P_o n$ and the fuel will then last $6.15\lambda/\gamma P_o n$ hr. at full throttle and maximum speed. The range of flight, with all n engines going, is in general terms $6.15\lambda V/\gamma P_o n$. If in this expression the values of $P_o n$ and W be substituted

$$\text{Range (in miles)} = \frac{6.15\lambda V}{\gamma \dfrac{WV}{375\eta}\left(\dfrac{D}{L}\right)_e} = \left(\frac{L}{D}\right)_e \frac{6.15\lambda V \times 375\eta}{\gamma WV}$$

$$= \left(\frac{L}{D}\right)_e \frac{2306.25\lambda\eta}{\gamma(nM + L_a + 160p + 6.15\lambda)}$$

From Fig. 10, if the equivalent linear dimension be designated by $A^{0.5}$, where A = area, the weight will be proportional to $A^{2.6/2.0}$. The weight of the airplane can then be expressed as $L_a = \mu W^{2.6/2.0} = \mu W^{1.3}$. The engine weight, when expressed in terms of the available power, is $nM = vP_o n$, where v is the unit weight per brake-horsepower. Therefore,

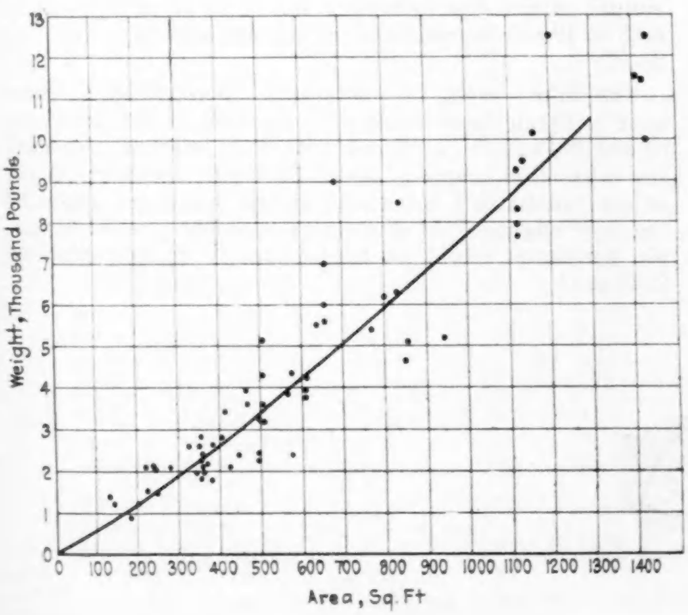


FIG. 10

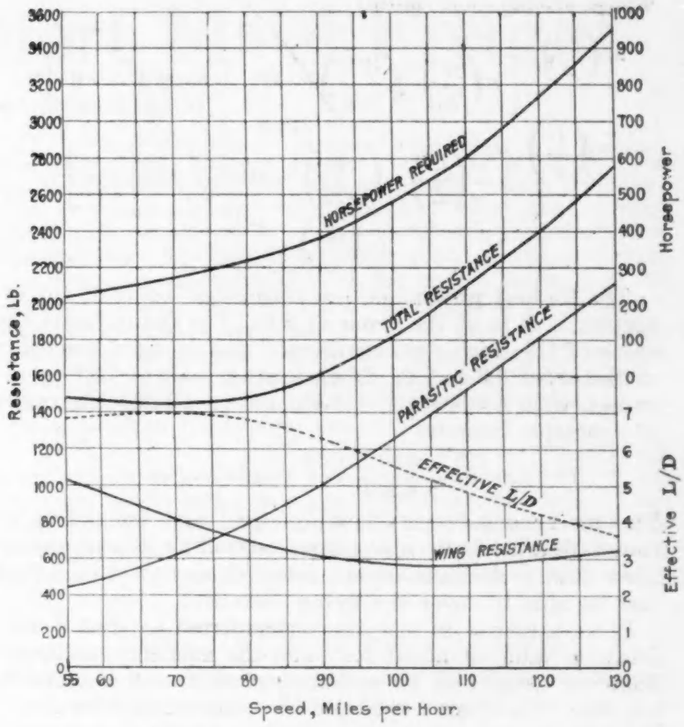


FIG. 11

$$W = v\left(\frac{D}{L}\right)_e\left(\frac{WV}{375\eta}\right) + \mu W^{1.3} + 160p + 6.15\lambda$$

If now cW be substituted for $(160_p + 6.15\lambda)$, the following complete expression in W will result:

$$W = \frac{v}{\eta}\left(\frac{D}{L}\right)_e\left(\frac{WV}{375}\right) + \mu W^{1.3} + cW$$

Dividing this equation by W

$$1 = \frac{v}{\eta}\left(\frac{D}{L}\right)_e\left(\frac{V}{375}\right) + \mu W^{0.3} + c, \text{ hence}$$

$$c = 1 - \frac{v}{\eta}\left(\frac{D}{L}\right)_e\left(\frac{V}{375}\right) - \mu W^{0.3}$$

In flying-boat construction the dead load of the hull, panels, etc., will constitute at a minimum about 35 per cent of the total load, or $L_a = 0.35\ W$. But as L_a has been shown to be equal to $\mu W^{1.3}$, $0.35W = \mu W^{1.3}$, from which

$$\mu = \frac{0.35}{W^{0.3}}$$

Assuming for W the approximate value of 25,000 lb.,

$$\mu = 0.0015$$

The propeller efficiency may be taken at about 80 per cent and a current value of 2 lb. per b.hp. for v. For the complete machine the L/D value will be of the order of 6.9 for the maximum values.

If a velocity of about 115 m.p.h. be approximated and the foregoing values substituted in the expression for c,

$$c = 1 - \frac{2.00}{0.80}(0.145)\left(\frac{115}{375}\right) - 0.35$$

$$= 0.54 \text{ maximum to } 0.50 \text{ average}$$

If a crew of four men be included the weight will be 640 lb. or $0.026W$, and the fuel may be regarded as $0.475W$ to $0.50\ W = 6.15\lambda$.

Range of operation (miles)

$$= \left(\frac{L}{D}\right)_e \frac{375\eta \times cW}{\left[v\left(\frac{D}{L}\right)_e\left(\frac{WV}{375\eta}\right) + \mu W^{1.3} + 0.026W + cW\right]\gamma}$$

$$= \left(\frac{L}{D}\right)_e \frac{375\eta c}{\left[\frac{v}{\eta}\left(\frac{D}{L}\right)_e\left(\frac{V}{375}\right) + \mu W^{0.3} + 0.026 + c\right]\gamma}$$

$$= \left(\frac{D}{L}\right)_e \frac{375\eta c}{\gamma}$$

The highest present design theoretical value of the effective L/D is of the order of 9.0. For flying boats the value of this factor is considerably lower, more generally of the order 6.8 to 7.0. If an average value of 6.9 be assumed, with $\eta = 0.80$, $c = 0.50$, and $\gamma = 0.525$, the range of operation becomes

$$6.9 \frac{375 \times 0.80 \times 0.50}{0.525} = 1975 \text{ miles}$$

The distance between Newfoundland and Ireland is in round figures 2000 miles, and preceding computations show that a machine of the given characteristics would just be able to cover the flying distance.

If an increase in size be contemplated so that c may attain a value of about 0.52 and the efficiency of large-diameter propellers be reckoned at 0.82 and this value has been consistently obtained in recent designs by me,

$$\text{Radius} = 6.90 \frac{375 \times 0.82 \times 0.52}{0.525} = 2100 \text{ miles}$$

If all quantities be taken at their extreme values, a maximum range of 2300 miles is obtainable, giving an excess for deviation in flight of 15 per cent.

The results obtained in the foregoing calculations will now be compared with the performance curves of a 10,000-lb. flying boat, Fig. 11, and deductions as to size, capacity and flying speeds will be made. The model in question carries 330 gal. of gasoline. Equipped with two Liberty engines, it would have a maximum speed of about 110 m.p.h. This gives a straight-ahead flying range of 550 miles with both engines working. It is thus obvious that at least 4.5 to 5.0 times as much fuel must be carried in a craft of this type to make the trip possible. Hence the fuel load must be 330 times 5.0 or 1650 gal. of gasoline on a two-engine assumption. This corresponds to a load of 10,150 lb., on the assumption of two engines. Hence if the machine be equipped with n engines the total gasoline load will be 10,150 $(n/2)$ lb.

From the above considerations the indications are that the new machine will be roughly 2.5 times the weight of the first and be about 1.75 times as large, hence the horsepower requirements may be estimated at $\frac{m\sqrt{m}}{N} HP_b$ = 2.25, say, 2.0, where m = ratio of weights and HP_a = 2.0 HP_b = 2 × 2 engines. We can thus estimate on a four-engined machine, for which the fuel must now be computed at 10,150 × 4/2 = 20,000 lb. approximately. The new machine weight can now be estimated as follows:

Fuel, lb.	20,000
Four engines and equipment, lb.	3,600
Crew of three men, lb.	450
Dead load of machine, lb.	8,000
Total weight, lb.	32,050

The total weight would therefore be about 32,000 lb. The approximate wing area (R. A. F. No. 15) is given by the formula 32,000 = 0.002958 × 3025 × A (for 14-deg. angle of incidence) = 3570 sq. ft. The ratio of linear dimensions N is 1.77:1, and the ratio of weights m is 3.14:1.

Investigating the problem, we have $N = 1.77$; $m = 3.14$, hence

$$V_a = \frac{\sqrt{3.14}}{1.77} V_b = V_b$$

The velocities correspond. Also,

$$\text{Thrust}_a = 3.14 \times \text{Thrust}_b \text{ and}$$

$$HP_a = \frac{3.14\sqrt{3.14}}{1.77} HP_b = 3.14 HP_b$$

The original type had 800 hp. in two engines. If the new machine were to fly at 100 m.p.h., the effective L/D would be 5.50, which would considerably lower the radius of flight. However, at 80 m.p.h. a value of 6.90 may be realized for the L/D factor. Further, the horsepower requirement at this speed is 320, as compared to 600 for the basic machine. If the new machine be equipped with four engines of the high-compression type, the available horsepower = 0.82 × 4 × 430 = 1410. This is equivalent to the 1410/3.14 = 450 hp. flying requirement in the basic machine, about 97 m.p.h., hence a flying speed of 95 m.p.h. may be counted on, with an effective L/D of 6.0. If the course as laid out were 2000 miles and 300 were allowed for variation, the trip would require 24 hr. With the four engines running continuously the total weight of gasoline necessary would be 33 × 4 × 24 × 6.15 = 19,500 lb., whereas the contemplated quantity was 20,000 lb.

The flight could be successfully accomplished, then, with a flying boat, similar to existing types, of about 32,000 lb. weight, equipped with four engines and having a gasoline supply of about 3250 gal., assuming flight at continuous full speed and at the maximum speed of the four engines. At economical speed the gasoline supply necessary would be approximately 85 per cent, or 2760 gal.[4]

[4] The NC-4, with a total weight of 28,000 lb., flew 1390 miles in 15 hr. 18 min., and carried a gasoline load of 1650 gal.

Motor Trucks for Short Haul Freight[1]

By W. J. L. Banham[2] (*Non-Member*)

USERS of motor trucks should consider to what extent they can be operated in competition with short-haul freight movement. The principles involved are, first, service, and, second, cost. To make a fair comparison between these two means of transportation, it is important that the manufacturers be in a position to know the cost of moving less-than-carload shipments via freight, particularly to short-haul points. They should also know the cost of transportation via motor trucks covering the same shipments.

Sometimes manufacturers figure that when a freight rate is 50 cents per 100 lb. via freight, and the rate to the same point via motor truck is 75 cents per 100 lb., this in itself shows an increased transportation cost of 25 cents. This is not a fair comparison and is not a true cost. What I understand to be a transportation cost is all expense involved in making a shipment, starting with the boxing or packing expense, and all other expenses incurred until delivery is made to the receiver in good order. It is not an easy matter, however, for the manufacturer to compile all these costs, as freight shipments involve expense through various departments, some of which can be figured out, while the others are usually carried as a department expense. If shipments are not made by the cumbersome freight method, the cost can be materially reduced if other means are used to make freight shipments to short-haul points.

Comparative Cost of Figures

I am firmly convinced that motor-truck transportation will reduce the shipping costs of the manufacturers considerably and eliminate a number of transportation evils which are both costly and annoying to shippers and receivers of freight alike. For the information of this conference I have compiled some figures showing the cost of freight movement compared with

COMPARISON OF COSTS BETWEEN FREIGHT MOVEMENT AND MOTOR-TRUCK TRANSPORTATION

	Cost per 100 lb.	
	Via Freight	Via Motor Truck
From Yonkers, N. Y., to—		
Newark, N. J.	$1.04	$0.20
From New York City to—		
Newark, N. J.	0.91	0.15
Passaic, N. J.	0.91	0.18
Paterson, N. J.	0.91	0.20
Elizabeth, N. J.	0.91	0.20
New Brunswick, N. J.	0.91	0.40
Trenton, N. J.	0.98	0.60
Philadelphia, Pa.	1.02	0.80
Chester, Pa.	1.05	1.00
Wilmington, Del.	1.13	1.20
Coatesville, Pa.	1.15	1.05
Port Chester, N. Y.	1.02	0.63
Greenwich, Conn.	1.02	0.63
Stamford Conn.	1.03	0.65
Norwalk, Conn.	1.06	0.68
Bridgeport, Conn.	1.10	0.70
New Haven, Conn.	1.13	0.73
Derby, Conn.	1.13	0.73
Ansonia, Conn.	1.13	0.73
Shelton, Conn.	1.13	0.73
Naugatuck, Conn.	1.15	0.74
Waterbury, Conn.	1.16	0.75
Meriden, Conn.	1.16	0.75
Hartford, Conn.	1.21	0.90
Springfield, Mass.	1.25	1.00
Holyoke, Mass.	1.25	1.10
Worcester, Mass.	1.31	1.50
Boston, Mass.	1.36	1.50
Providence, R. I.	1.32	1.10

[1] Address, substantially in full, delivered at the Ninth National Truck Owners' Conference, New York City.
[2] General traffic manager, Otis Elevator Co., New York City.

the same movement via motor truck. These figures are worked out on an average basis and, while substantially correct, they may not cover local conditions which exist in various shipping departments. I have included in the freight cost the first-class rate plus 15 cents per 100 lb. teaming charges from the shipper's warehouse to the freight house, plus the same teaming charge from the freight house to the receiver's warehouse, plus 24 cents per 100 lb. to cover the increased cost of boxing shipments made via freight, plus 17 per cent on account of the increased weight caused by the boxing. I have not included in this amount considerable additional expense, to which I will refer later.

The rate via motor truck covers delivery from the shipper's warehouse to the receiver's warehouse. I have averaged this rate and believe it is a fair one to use in comparison with the freight cost movement. With this explanation I will now give the cost of transportation, showing the difference in transportation cost between freight movement and motor-truck movment.

Extra Cost of Freight Shipments

I will now consider some of the additional expense covered by freight movement. In practically every instance it is necessary to prepare material for freight shipment in an entirely different way than if it be moved via motor truck direct from the shipper to the receiver. It is necessary to go to considerable additional expense for boxing or crating, or to protect the goods by other means, in order to prevent loss or damage in transit. This additional packing expense is necessary on account of the number of handlings the less-than-carload shipments receive at the hands of the teamsters and carriers after the material leaves the shipping department. This added protection and expense can be greatly reduced if shipments are made via motor truck, and the packages only need protection for loading at the shipper's warehouse, in transit without transfer and unloading at the receiver's warehouse.

After the shipment has been properly prepared for transportation, and the necessary shipping documents are made out, delivery must be made to the local freight house, either by truck or other means, which increases the transportation cost to the amount of the teaming and additional labor. The shipping department is burdened with an additional expense covering the transfer of this freight from shipping floor to carrier's freight house. If the freight is to be prepaid, the freight bill when rendered must be checked by the shipping department and passed for payment through the interested departments. This does not involve any considerable expense where one or two freight bills are considered, but in a large shipping department, where hundreds of shipments are made daily, it is necessary to go to considerable expense to check freight bills as to their correctness in classification, weight and rate, which is an additional transportation cost, and makes necessary the entering of claims against the carriers for overcharges, which is a further transportation cost.

I will now assume that the shipment is in the hands of the carrier to be transported to a short-haul point. The customer is notified that shipment has been made and is usually furnished with a copy of the bill of lading as evidence that shipment has been made. It would seem now that the transportation cost has been completed, but this is not the case in a great number of instances. Shipments, moving via freight, are subject to delay, and the time in transit may be anywhere between 6 days and 6 weeks. When shipments are delayed the receiver of the freight, as a rule, asks for a tracer to be started, which usually involves considerable correspondence, together with labor, and is an additional transportation cost.

When the material finally arrives at its destination the receiver is subjected to additional expense, as it is necessary for him to arrange for the transfer of the freight from the local freight house to his warehouse. This also involves a teaming charge, both of which are additional transportation costs. If delivery is made in full and in good order, no further action on the part of the receiver is necessary other than the payment for the material under terms arranged and agreed upon. If the shipment arrives, however, in part only, or in a damaged condition, it is necessary for the receiver or the shipper to locate the missing packages or replace them or duplicate such parts of the shipment as are damaged. This involves additional expense and is part of the freight transportation cost.

Shipping by Motor Truck

I will now take a similar shipment which is to move via motor truck. It is not necessary to go to the same expense for packing or boxing, as there is usually no transfer in transit and only two handlings, since the packages are loaded by the shipper at his warehouse and are as a rule unloaded at the receiver's warehouse, usually without transfer. Practically none of the additional expense incurred by freight movement is necessary when the movement is made via motor truck. If a fixed rate is agreed upon, the shipper is in position to know how much his shipping charges will be. I consider that one of the greatest savings made possible by motor-truck transportation is in lumber and other material used for packing, together with additional labor and other charges incident thereto. The amount of this saving, however, will be controlled largely by the material to be boxed or packed and how much less protection can be used when moving via motor truck as against a less-than-carload movement via freight. Have you taken into consideration the amount of material you have in transit which is not producing any revenue, either to the shipper or the receiver, while it is in the hands of the carrier? The average receiver of freight apparently does not consider invoices for material due until delivery has been made, regardless of whether the material is sold f.o.b. shipping point or f.o.b. delivery point. If terms of sale are 2 per cent 10 days, or net 30 days, he usually takes 10 or 30 days from the receipt of freight. If goods are in transit 30 days, it means that you are selling on 60 days' credit, instead of 30 days. If delivery can be made within 24 hr. via motor truck, there could be no question about when the invoices are due, and the money could be used for further manufacture or in any other way decided upon by the shipper.

Have you considered the amount of space you use in your shipping departments to prepare your shipments to move via freight? Have you considered how much less space you need in your shipping departments if you can materially reduce the amount of boxing and packing used on your shipments? Have you considered the amount of lumber it is necessary for you to carry for boxing and the space necessary to store it, and the amount of freight charges you pay on wet lumber, if it is stocked in the open, as is usually the case? Boxing lumber will frequently carry from 10 to 25 per cent of its weight in moisture, unless it is passed through a dry kiln before being used for boxing purposes. Could you not use any space which can be saved by changing your shipping methods for manufacturing purposes, which would produce a profit, instead of an expense?

Is it not to your advantage to make delivery to your customer within the shortest possible time? The best advertising feature which Marshall Field & Co. of Chicago have is that they agree to make delivery within 50 miles of their store within 24 hr. It is true that this increases their delivery cost over and above a slow freight movement, but prompt delivery gets the business and slow delivery would lose it.

Have you considered the amount of material and money your company has tied up, by reason of the fact that you are unable to state definitely how long it will take to effect a freight movement between your factories and your customers? If a freight shipment takes 30 days as against 1 day via motor truck, would it not be to the advantage of your company to use the difference in time, 29 days, for manufacturing? Have you considered the amount of expense to the manufacturers to store and handle their products on account of uncertainty of freight delivery?

In general, I am of the opinion that motor-truck transportation can, and should, compete successfully with the railroad carriers to short-haul points. The delivery time is all in favor of the motor trucks, and I am satisfied that if the manufacturers will take into account all the various costs and charges which are part of a freight transportation cost, motor trucks can be operated successfully in competition with the rail and water carriers for distances of between 10 and 125 miles.

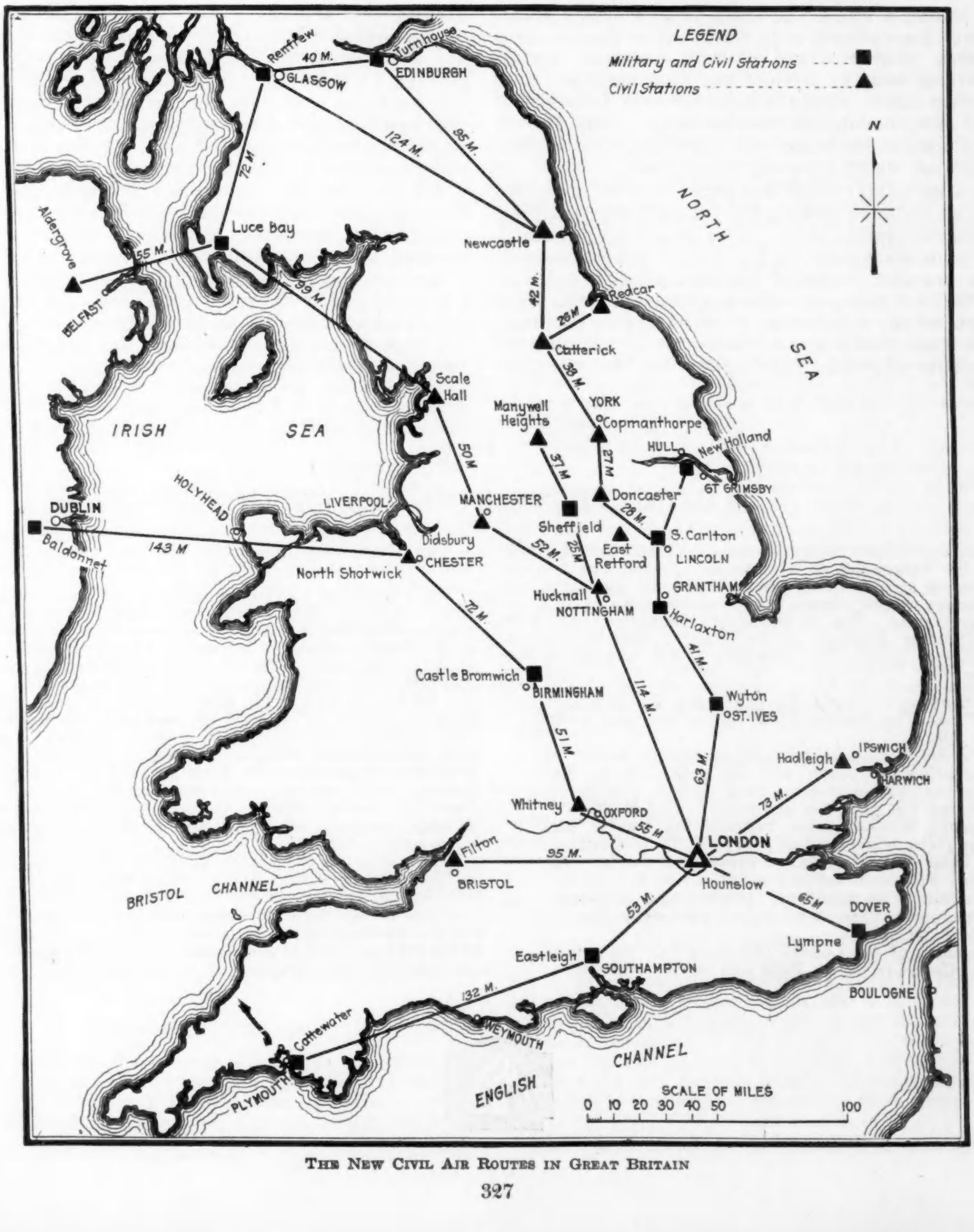
STANDARDIZATION

A COMMUNICATION received recently from C. G. Wood, chief engineer and general superintendent of the Hoosier Auto Parts Co., indicates clearly the value of the standards work of the Society in an emergency such as the war. Few members indeed have any lack of comprehension of the usefulness of standardization in commercial work, and all will be interested in Mr. Wood's remarks. Mr. Woods was in the service of the Government for nearly 2 years as a commissioned officer, spending a year with the A. E. F. and 8 months as assistant to the chief purchasing officer of the Motor Transport Corps and being at another time chief inspector of the Motor Transport Corps Overhaul Park at Le Mans, France. He says, "I was interested in the Society of Automotive Engineers long before I became a member several years ago but never appreciated the full value of the organization until entering the service. For the last 8 months before going to France, I was officer in charge of a district where the Government was having some of the Class B motor truck assemblies manufactured. This enlightened me somewhat on the great work being accomplished by the Society with its standardization program but even then I did not realize what had been done along these lines. When I started to purchase every kind of supplies in the A. E. F. for our Department, I immediately began to realize and marvel at the great amount of work that had been and was then being done along the lines of automotive standardization in the United States. In many cases we were unable to locate the repair parts or supplies required but with the aid of my S. A. E. data sheets I was enabled to go out and get them manufactured with no difficulty. If it had not been for the standardization of automotive parts we would not have been able to take care of one tenth of the enormous demand on the Motor Transport Corps.

Civil Flying in Great Britain

ON Nov. 11, when the armistice was signed, there were in Great Britain and Ireland 337 airdromes and landing grounds, the latter being for practical purposes the same as an airdrome with less air facilities and accommodations. Of these 116 have already been relinquished for cultivation, etc., while about 100 will be required for the time being by the Royal Air Force. There remain, therefore, about 120 airdromes and landing grounds which will ultimately be available for civil aviation. At many of these there are extensive buildings, and it is possible that with the progress of civil aviation town councils, public bodies or important commercial firms interested in the subject, may be disposed to avail themselves of the opportunity of acquiring a going concern in an airdrome equipped with ready-made accommodations.

Owing to the necessity for completing existing contracts for material and for maintaining the power of remobilization in case of necessity and to the sudden cessation of the war wastage of equipment overseas,



THE NEW CIVIL AIR ROUTES IN GREAT BRITAIN

the demand for storage accommodation in England at the moment is very great. This implies that at many of the airdromes marked for ultimate disposal, the buildings will for some time be largely required for service machines, causing a deficiency in storage facilities which may prevent potential purchasers from taking over the airdromes. The question of storage accommodation, however, is one of a temporary nature, and as conditions become more normal the situation will become easier owing to military equipment being relegated to military airdromes. In the meantime a certain easement may be effected by the erection of Bessonneaux and temporary hangars.

In spite of the storage and other difficulties, the Government has decided to open up certain trunk air routes at once. These routes have not been laid down arbitrarily by ruling a line on the map from place to place. They have been chosen with reference to the situation of existing airdromes and military demands, and in their arrangement an attempt has been made not only to establish direct communication between London and Ireland, and London and the North, etc., but also to cater for some of the larger and more important centers of population which lie along the routes.

Once a particular route has been declared open, the pilot of an airplane making the journey will find fuel, some accommodation and, where possible, mechanics to handle his machine at each of the air stations named, and the practical value of the intimation now given lies in the fact that any individual who complies with the terms of the regulations is at liberty to fly along these civil air routes and to make use of the stations and facilities afforded. It is pointed out that the Government cannot guarantee to assist aircraft which may land elsewhere than at a specified station.

At these appointed airdromes all outward and inward bound aircraft must land for examination of goods and passengers. It has been suggested that they would be better situated inland and not on the coast, argument being that much of the time gained by air transit of goods would be lost if examination had to be carried out immediately on crossing the seaboard; but the difficulties of control if such a system were adopted and the lack of certainty as to what particular channels trade will follow have led to the provisional placing of them on the coast.

Hitherto, the Air Ministry points out, much of the progress in aviation has been due to war conditions, and it follows that at first the majority of machines used in civil aviation will be either actual war models or war models adapted. Types more suitable for pleasure and commercial work are, however, already beginning to make their appearance, and for them, as has been the case with the earlier war models, rigid care and supervision in regard to construction and air-worthiness will be insisted upon for the safety of the traveling public and also of the public in general.

The Air Ministry will not in any way hinder development by imposing inspection on inventions or purely experimental machines, but it will insist on the inspection and certification for general air-worthiness of any passenger machine plying for hire. Not only the machine, but the pilot who carries passengers and the airdrome where he lands will be subject to periodical inspection, and if they are not passed as fit the license may be withdrawn.—*Aeronautics*.

NOMINATIONS FOR 1920 OFFICERS

THE Annual Nominating Committee of the Society, provided by Paragraph 46 of the Constitution, has submitted the names of consenting nominees for the elective offices of the Society which become vacant at the close of this administrative year. The Nominating Committee organized at the Summer Meeting of the Society held in June at Ottawa Beach, Mich. The nominees of the Committee are as follows:

For President (to serve for one year), J. G. Vincent.

For First Vice-president (to serve for one year), J. G. Utz.

For Second Vice-president, representing motor car engineering (to serve for one year), W. G. Wall.

For Second Vice-president, representing aviation engineering (to serve for one year), G. L. Martin.

For Second Vice-president, representing tractor engineering (to serve for one year), H. C. Buffington.

For Second Vice-president, representing marine engineering (to serve for one year), C. A. Criqui.

For Second Vice-president, representing stationary internal-combustion engineering (to serve for one year), L. M. Ward.

For members of the Council (to serve for two years), F. M. Germane, N. B. Pope and A. W. Starratt.

For Treasurer (to serve for one year), Chas. B. Whittelsey.

The number of the voting members of the Council is fifteen. President Manly will be a member of the Council next year as Past-president, and the terms of Councilors E. A. De Waters, David Fergusson and E. A. Johnston will not expire until 1921. The Nominating Committee was composed of three members at large elected at the Business Session of the Semi-Annual Meeting held in June and eight members elected by Sections of the Society as follows:

F. E. Moskovics (chairman), Indiana Section; B. B. Bachman, Pennsylvania Section; J. T. R. Bell, Buffalo Section; J. L. Mowry, Minneapolis Section; M. A. Smith, Mid-West Section; J. E. Schipper, Detroit Section; J. V. Whitbeck, Cleveland Section; W. H. Conant, G. P. Dorris and C. C. Hinkley, members at large; and C. F. Scott (secretary), Metropolitan Section.

Ballots bearing the names of candidates for the offices to be filled will be mailed to the voting members prior to the 1920 Annual Meeting of the Society to be held at New York, Jan. 6 to 8. At the first session of this meeting three tellers will be appointed by the President to canvass the ballots cast by the members and to certify the result of the election in accordance with the By-Laws of the Society.

The Acid Bessemer Process

By Richard S. McCaffery[1] (*Non Member*)

PRESENT American practice with large acid Bessemer converters is about as follows:

The iron, which has been taken from blast furnaces in the molten condition and then poured into a mixer, is drawn, as required by the converters, from this mixer into a transfer ladle and poured into the down-turned converter which has a capacity of about 25 tons. The air blast is now admitted, the converter turned up and the elimination of the silicon, manganese and carbon is rapidly carried on. The blast pressure usually employed varies between 20 and 25 lb. per sq. in. at the converter, and if it be necessary during the blow to cool the converter contents, arrangements are made for the addition of scrap steel, or, in plants where scrap steel can more advantageously be sent to the open hearths, provision is made to cool the converter by blowing in steam with the air. The time of the blow depends on the amount of impurities eliminated, the design of the converter bottom, and the blast pressure; but generally, with a 25-ton vessel, it is between 10 and 15 min. When the contents of the converter have reached the desired carbon, or when soft blown, the converter is turned down, the blast cut off, and the vessel contents poured into a ladle.

The Problems Attacked

Recently I had the good fortune to witness many Bessemer blows and to take samples and temperatures at various stages of the blow with the object of determining whether the reaction whereby the manganese in the pig iron is eliminated as an oxide is a reversible reaction and, if reversible, a possible method of keeping the manganese in the blown metal and also for determining means of preventing "spitting" which takes place in the latter part of the Bessemer blow with certain irons. This spitting is very objectionable and largely increases production costs on account of the necessity of regular clean-ups to gather together the slag and metal ejected from the converter.

To determine the reversibility of the manganese oxidation reaction, a series of samples was taken of the mixer metal, the converter contents at the end of the silicon blow in 4 min. from the start, in the middle of the carbon blow in 8 min. from the start and of the soft blown metal. Slag samples were taken at the same time, and the temperature of the metal was observed by a pyrometer. In certain of these tests residual manganese was obtained, but not generally, while in some of the tests, when a temperature of 1830 deg. cent. was attained by the blown metal, the manganese was entirely oxidized. In regard to the spitting, it had been observed that this was worse with a low-silicon, high-manganese pig iron, about 1 per cent silicon and with 1.75 to 2 per cent manganese, and also that it was much worse the higher the temperature at which the converter was operated.

After a study of all the data obtained was made, the following explanation seemed to account for all the difficulties and suggested improvements in the practice. In the following discussion phosphorus is not considered, as it is not eliminated in the acid Bessemer process, and sulphur is neglected, as its effect on the heat balance is so small as to be negligible compared with the silicon, manganese and carbon. The silicon and carbon of the iron form respectively silicides and carbides of iron and manganese.

Reactions in the Blow

In the converter the carbides of iron and manganese may burn to form carbon dioxide in greater part, if the temperature is low and to form carbon monoxide in greater part if the temperature is high. The net heat of combustion in the converter of these carbides and silicides is figured below.

Substance	Formula	Oxidation Product	Calories per Gram Atom of Metal
Silicide of iron..........	FeSi	Fe_3O_4 and SiO_2	245
Carbide of manganese....	MnC_2	$MnO—CO_2$	171
Silicide of manganese.....	Mn_7Si_2	$MnO—SiO_2$	135
Carbide of iron..........	Fe_3C	Fe_3O_4 CO_2	98
Carbide of iron..........	Fe_3C	Fe_3O_4 CO	75
Carbide of manganese....	MnC_2	MnO CO	35

They are arranged with the greatest heat of combustion first, in other words the arrangement is in the order that oxidation occurs, the silicide of iron burning first and carbide of manganese, when the carbon burns to carbon monoxide, remaining until last. It is assumed that the iron burns to magnetic oxide, as that reaction liberates most heat.

With these thermal data, the cycle of the acid Bessemer blow will be considered. The iron silicide burns first, forming magnetic oxide of iron and silica, and, as a result of the high combustion heat, the temperature of the converter rises. If the bath is not at too high a temperature now, the manganese carbide burns, the carbon becoming carbon dioxide. In this discussion I assume that the iron silicide burns completely first; then the manganese carbide begins. This, however, is not the real condition. I believe all the reactions take place at the same time to a greater or lesser extent, but at one time some one reaction is taking place more rapidly than it does at other times, that it is predominating at some time over the other reactions. When I state that one reaction takes place and then another reaction follows it, I mean that in this general way some one reaction is predominating at one particular time.

The oxidation of the manganese carbide, at the lower temperature which I have assumed in the converter, produces manganese oxide and carbon dioxide, and the oxide of manganese, along with the magnetic oxide of iron, forms with the silica, previously produced, an iron manganese silicate slag. The temperature is rising now, and the iron carbide burns, and for this discussion it is immaterial whether the carbon of the iron carbide burns to carbon dioxide or to carbon monoxide. When the carbon of the iron carbide is burned out, the acid Bessemer process is completed, as the manganese carbide has been previously burned. The vessel is turned down and poured, and we have what might be called a normal blow, the temperature of the blown metal being 1600 and 1650 deg. cent., and no trouble of any kind has been experienced.

Effect of High Temperature

With this normal blow, contrast what takes place if the temperature of the converter is raised and the blown metal is excessively hot. We start in with the second blow and first burn, as before, the silicide of iron to magnetic oxide of iron and silica. The temperature of the mixed metal may have been higher or more silicon may have been in the pig iron, but, as a result, after the silicon of the iron has been burned, on account of the high temperature, the silicide of manganese now burns and the manganese carbide remains in the molten metal. This manganese carbide now begins to cause trouble. It is a very active reducing agent, and it begins to reduce the silicon in the silica to metallic silicon and the magnetic oxide of iron to ferrous oxide, both of which results are detrimental because the slag is made more basic, first by the reduction of the silica and secondly because the magnetic oxide may form with ferrous oxide or manganese oxide a certain amount of ferrite slag.

This possibility of ferrite formation is prevented by the

[1]Professor of metallurgy, University of Wisconsin, Madison, Wis.

reduction of the magnetic oxide to ferrous oxide. The net result of this increase of basicity of the slag is to render it more infusible, which again results in the spitting phenomenon. This continues until all the manganese carbide has been eliminated by reducing the silica and the magnetic oxide. The iron carbide now oxidizes and the manganese carbide continues to reduce the silicon until the manganese carbide is itself completely burned. Then, with the elimination of the carbon of the iron carbide, the blow is finished and the vessel turned down.

Conclusions Reached

The answer can now be made to various questions proposed in the beginning of this paper.

Is the reaction $2\ Mn + O_2 = 2\ MnO$ a reversible reaction at the temperatures possible in a Bessemer converter? It is not, because many blows were finished at 1820 or 200 deg. cent. above the normal temperature, and in these blows the manganese was completely oxidized. How about certain blows in which residual manganese was formed? In these blows, the silicon in the pig iron was always high, and the silicon was always residual with the manganese, the explanation being that the early and middle parts of the blow were carried on at a high temperature, causing the manganese carbide to stay behind in the metal and reduce the silica. In these latter blows the drop of the flame is not so clear and certain as in normal blows and when the iron carbide is completely burned the flame appears to drop somewhat and the converter is turned over. However, there is always sufficient carbon remaining in these blows to combine with the manganese, and the manganese in the blown metal is not residual from the reversibility of the oxidation reaction but from the presence of some manganese carbide, while the residual silicon in them results from the reduction of the silica by the reaction of some of this manganese carbide.

The spitting can be cut down or entirely eliminated by temperature control during the blow, and, to secure this regulation, the steam line into the converters experimented with was increased in size because scrap was not available to add to the hot charge to lower its temperature. By steaming during the silicon blow and thus keeping the temperature down the manganese carbide is burnt out early, its detrimental reducing action is prevented and the spitting stopped. During the experimental work, under certain conditions, it was observed that the converter temperature rose rapidly during the carbon blow, which of course it should not do. This indicated the possibility that the carbon monoxide in the converter was being burned in the vessel to carbon dioxide, a result not desired as it made the temperature higher, necessitating the use of steam or scrap, either of which increased the cost; and in addition, more power was used in the blowing engines to furnish oxygen to burn the carbon monoxide in the vessel when it might just as well have been discharged into the atmosphere and burned there.

A New Converter Bottom

With these considerations in mind, a new converter bottom was designed, increasing the number of the tuyeres and changing their distribution, and a test was made of the new bottom in comparison with the old. On account of the difficulty of installing air measuring apparatus, the blowing engines which had been previously indicated under various operating conditions both on the steam and air ends were used as an air meter. Two consecutive pours from the mixer were blown so as to obtain, as nearly as possible, the same quality of metal, and these ladles were separately blown by the same blowing engine, with only the one engine on the blast main. Both charges were blown soft. The result follows:

	Old Style Bottom	New Style Bottom
Number of ⅝-in. tuyeres	23	35
Weight mixer metal, lb	47,000	50,000
Blast pressure at engine, lb. per sq. in	28	22
Total engine revolutions per blow	589	443
Time of blow, min	14	10⅓
Comparison of time, per cent	100	69
Comparison of power, per cent	100	60

This test indicated the cause of certain of the troubles. As a result of the high air pressure employed with the old converter bottoms, large amounts of air were blown through the molten bath without oxidizing the impurities but, instead, burning the carbon monoxide in the vessel to carbon dioxide. In this case, as shown by the test, the time of blow is actually shortened, by reducing the blast pressure, equal to an increase in converter capacity of 45 per cent, with an actual saving in blowing power for the increased capacity.

Aside from this very obvious advantage, however, the reduction of the converter temperature and the control of the oxidation of the manganese carbide, with the elimination of spitting, are other advantages of the greater number of tuyeres and reduction of blast pressure with the new style of bottom.

Some of the temperatures obtained for certain Bessemer blows seemed so high that great care was taken to make certain that they were correct. Two observers with separate instruments could obtain checks on the temperature within 10 deg. cent. easily, and were usually within 5 deg. cent. The instruments were standardized twice a day, and as they gave normal readings for the normal blows there is no reason to believe that the high temperatures recorded for certain blows were incorrect.

At first glance it might appear that a comparatively old process like acid Bessemer does not offer many possibilities for research, but, after close study of the process, the need for and possibility of research become very apparent.—*The Iron Age.*

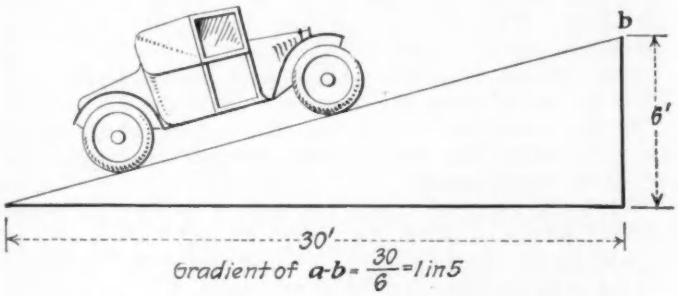
The Determination of Gear Ratios

PROBABLY the simplest formula which expresses the relation between power and the gradient to be climbed is the following:

$$\text{Horsepower} = \frac{\dfrac{d}{h}\,w}{33{,}000\,t} \quad \text{where}$$

d = total distance traveled in feet
h = distance traversed for a vertical rise of 1 ft.
w = total weight moved in pounds, and
t = time in minutes

In determining gear ratios the power available at a definite number of revolutions per minute is determined beforehand; usually 2000 r.p.m. is the speed taken, as



A Simple Example of What a Gradient Is

that is about the average at which engines are run. Also h represents the gradient, it being the distance traversed in feet for a vertical rise of 1 ft.; *i.e.*, for a gradient of 1 in 2, $h = 2$; for a gradient of 1 in 4, $h = 4$, and so on. We can estimate w pretty exactly, care being taken to add to the weight of the car and passengers that of the fuel in the tanks and such items as spare parts in locker, tools, luggage, etc. Of course the total weight of the car will vary considerably from day to day, but in working out the gear ratios it is advisable to reckon w as a maximum likely to be carried at any time.

A Simple Formula

Hence in the formula given above everything is known except d and t. Now $\frac{d}{t}$ is the speed of the car in feet per minute, so that when that is known the gear ratio necessary to give the car that speed in feet per minute with the engine running at 2000 r.p.m. can be easily determined. The formula now becomes:

$$\frac{d}{t} = \frac{33{,}000 \times p \times h}{w} \quad \text{where}$$

p = horsepower available at 2000 r.p.m.

The required gear ratio can be found from the following formula:

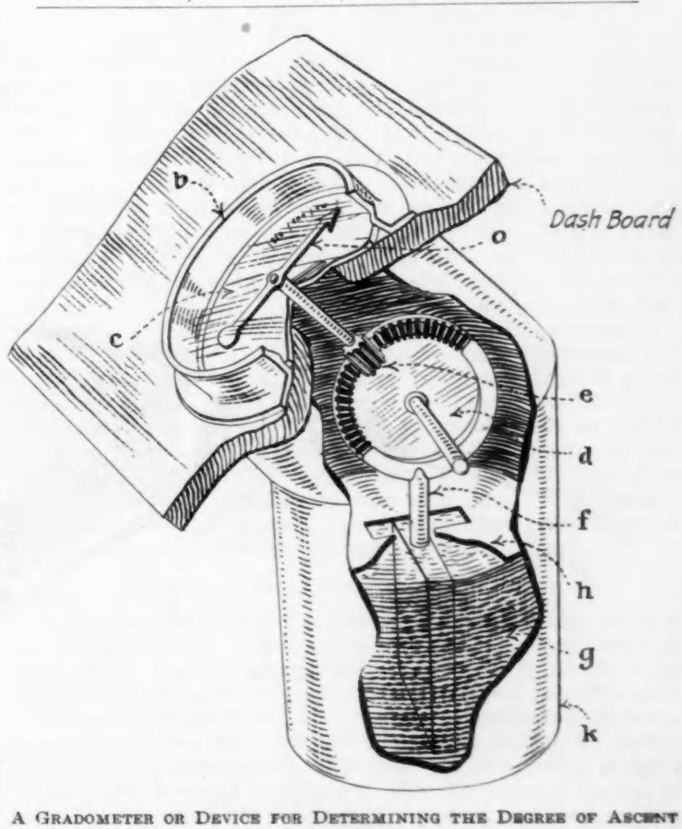
$$r = \frac{2000\,a\,t}{d} \times \frac{22}{7} \quad \text{where}$$

r = gear ratio required
a = diameter of wheel in feet
t = time in minutes, and
d = total distance traversed by the car in feet

Of course $\frac{d}{t}$ has already been found by the other formula; hence it is only necessary to invert it and insert it in the gear ratio formula. The accompanying table gives the gear ratio corresponding to any speed in feet per minute when the wheel diameter is 26 in. (2.166 ft.),

Gear Ratios for Different Speeds and Wheel Diameters

$\frac{d}{t}$	Gear Ratio 26 in.	Gear Ratio 28 in.	Gear Ratio 30 in.
88	154.700	166.600	182.500
176	77.350	88.330	91.350
264	47.600	55.550	60.890
352	38.680	41.670	45.670
440	30.940	33.330	36.540
528	25.780	27.770	30.420
616	21.100	23.810	26.100
704	19.340	20.830	22.740
792	17.190	18.520	20.300
880	15.470	16.660	18.250
968	14.060	15.150	16.610
1,056	12.890	13.890	15.230
1,144	11.910	12.820	14.060
1,232	11.050	11.910	13.050
1,320	10.290	11.110	12.180
1,408	9.670	10.420	11.420
1,496	9.100	9.804	10.750
1,584	8.590	9.258	10.150
1,672	8.140	8.772	9.620
1,760	7.740	8.333	9.140
1,848	7.367	7.936	8.700
1,936	7.033	7.575	8.305
2,024	6.726	7.246	7.943
2,112	6.446	6.940	7.595
2,200	6.189	6.670	7.310
2,288	5.950	6.410	7.030
2,376	5.730	6.170	6.770
2,464	5.530	5.950	6.530
2,552	5.340	5.750	6.300
2,640	5.160	5.540	6.090



A Gradometer or Device for Determining the Degree of Ascent of a Road

28 in. (2.333 ft.), and 30 in. (2.5 ft.). For other wheel diameters, the formula must be used, but wheel sizes other than those mentioned are not usual. To find the diameter in feet if millimeters are given, divide by 304.8.

An Application of the Formula

As an example, suppose it is required to find the low-gear ratio for a car which weighs 12 cwt. complete. The engine develops 11 hp. at 2000 r.p.m. and the wheel diameter is 28 in., the car to be capable of climbing a gradient of 1 in 4 on low gear.

$$\frac{d}{t} = \frac{33{,}000\,p \times h}{w}, p = 11, h = 4, \text{ and } w = 12 \times 112 \text{ lb.}$$

Thence, by substitution in above formula,

$$\frac{d}{t} = \frac{33{,}000 \times 11 \times 4}{12 \times 112} = 1080 \text{ ft. per min.}$$

From the table, the gear ratio required is between 13.89 and 12.82, nearer the former, or about 13.50. The exact value could be found by substituting in the formula

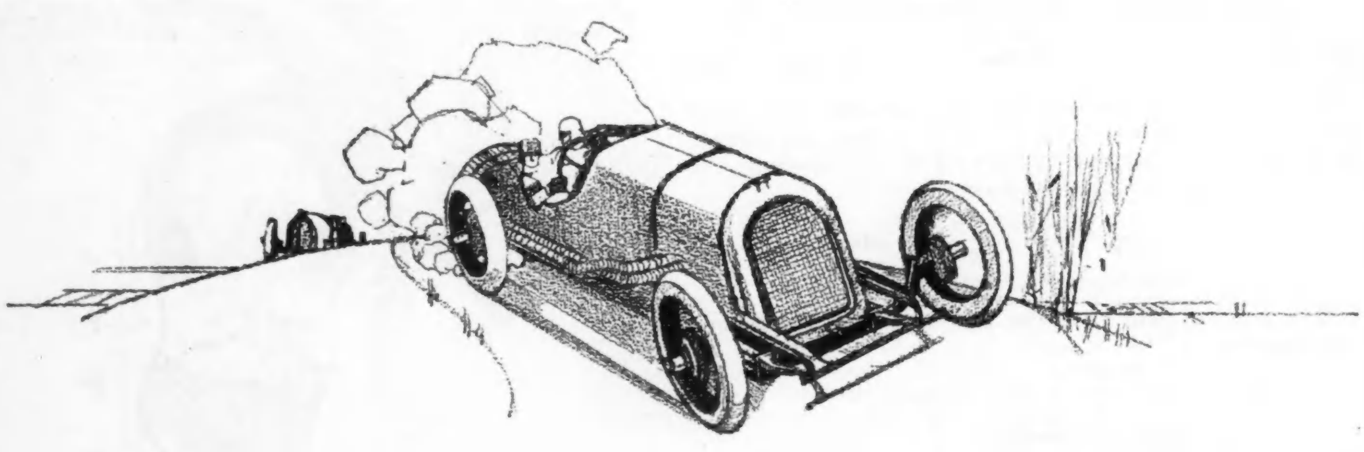
$$r = \frac{2000\,a\,t}{d} \times \frac{22}{7}$$

Gradients and Gradometers

It may not be out of place here to mention a few facts with regard to gradients and gradometers. The gradient of a line may be simply expressed as its slope. There has been a good deal of argument as to whether gradient should be measured as so many feet in a horizontal direction for a rise of 1 ft., or as so many feet measured along the slope for a rise of 1 ft.; but it is generally acknowledged now that the distance should be measured along the horizontal. In the accompanying gear ratio calculations it is assumed that the horizontal distance is the same as that measured along the slope. This is done to simplify the work so far as possible, and, in fact, in any ordinary road gradients the difference is negligible. In any case, no gear ratio calculations are absolutely unalterable, and neither is the speed of the engine; probably ninety-nine drivers out of every hundred accelerate their cars immediately on coming to a hill, so that the increased engine speed would more than outweigh any slight error involved in reckoning the horizontal distance equal to that measured on the slope.

A simple form of gradometer is shown in the sketch. It consists of a lead weight and suspension rod *f*, the weight being cast in rectangular form to offer the greatest amount of resisting surface to the oil *g* in the container. The lid *h* of this case has a slot cut in it to allow the rod *f* to swing. Attached to the rod *f* is a toothed wheel *d* which meshes with a small pinion *e*. This in turn carries the pointer *b*; *a* is the glass cover over the instrument, and *c* the card or face which shows the gradients. The bearings are omitted for the purpose of attaining clearness.

When the car goes uphill the weight swings in the direction shown, taking the wheel *d* with it. This, of course, moves the pointer *b*, it being driven by the small pinion *e* which meshes with *d*. On a decline the reverse occurs, and a fall is registered on *c*, the instrument being graduated to read either for a rise or for a fall.—*The Light Car and Cyclecar.*



What Will Become of Aviation?

THE British air routes, and especially those across the English Channel and the Irish Sea show most distinctly the great saving over any land and sea transportation combination. In this country the West Indies offer a similar comparison. In competition with the fast direct rail routes the air has not as yet much advantage in the short haul, and aviation is not perfected enough yet to be a serious competition of the long haul. But where the rail route is slow or not direct, air travel even today may have a place; for instance, across the Great Lakes, along the coast, into Mexico, or up into Alaska.

It will be very difficult to interest hard-headed capital or let the industry go ahead in competition with other countries unless the Government takes the necessary steps toward encouraging, and not discouraging, aviation.

To many the number of departments interested in aviation will at first seem to be logically answered by a separate department. It is extremely simple to draw up a hypothetical Utopia without regard to the many sides of the situation that stare us in the face, but usually Utopias do not work out practically anyway.

The laws and regulations of aviation must be drawn up nationally, and the supervision of these laws carried out effectively.

Will Congress decide to place this control of civilian and commercial aeronautics under the control of the Army and Navy or under a new bureau of say, the Department of Commerce, or will it establish a Department of Aviation?

Suppose that by some phenomenon the automobile had been delivered to this country in the state of mechanical perfection that is was in 1904, and there was not a road in the country. How much use would it have been? The present situation in aviation is almost analogous to such a supposition. To be sure, we have the air to fly in, but we lack landing fields, repair parks, proper meteorological reports, maps and the thousand and one accessories that will ultimately make aviation a great commercial success. Safety, certainty of delivery, reliability and regularity are essential. To get these, what are the necessary steps to be taken and what program are we going to lay out and adopt?

Take the situation as it is today in this country. The whole development of aviation has been toward war, and that war was in Europe. The manufacturer has turned all his brains and energy toward turning out planes for war purposes; every effort of the Government has been toward preparation for aerial warfare; flying fields and training centers have been built and run for that main purpose—to carry on and finish the war in Europe.

Now the war is over and public attention is centered on aerial navigation, partly by the spectacular part it has played in the war and partly by the romance it inspires. Enthusiasts carried away with the immense possibilities, politicians seeing political capital and pork barrel, propagandists seeing personal advantage are flooding the papers with misstatements and dealing in air futures without much regard to the basic problems confronting us. These problems, and there are many of them, will have to be overcome before aviation really comes into its own, as it surely will in time.

Leaving out the problems confronting the manufacturer and designer such as, to make the airplane safer, longer lived, capable of greater carrying capacity, etc., etc., we are faced with what uses it can be put to immediately and in the future. One Air Service major who has gone back to civilian life has made careful inquiries among business men to find out how often aircraft transportation would be used by them. His first question to the express companies, the banker, the manufacturer, etc., is this: Provided air transportation is reliable and regular, how often would a firm pay proportionately high rates for the increased speed of air transportation over ships and railroads? The answers are exceedingly illuminating, and they suggest many future and some immediate possibilities. But the great possibilities will not come until air travel is made safe and certain and regular. And air travel is not safe, certain, or regular today. The machines of today are safe. The percentage of forced landings in straight flying is small, but in such cases there are almost certain to be delays for repair or gasoline that will greatly hurt such service for commercial use.

The Problems Before Us

Almost the first essential thing for commercial use, and for that matter for civilian use, of the air is enough and adequate landing fields along the air routes. Landing fields with minor repair and supply shops are necessary, even as garages are necessary in every town for the automobile. The larger cities will have to provide, of course, great flying fields and shops. When a plane breaks a propeller, it cannot, if on a commercial run, wait 2 days for a new one from the factory.

There is always the possibility that mechanical ingenuity may overcome this and other drawbacks to rapid progress. A person who in 1906 knew we would never fly, or in 1914 knew there could be no world war because it could not be financed, if he has profited by subsequent happenings, is not going to say that airplanes will never settle like a bird on a piece of land the size of a tennis court and take off from it too. But until that time comes we shall have to maintain landing fields large enough to glide onto, and we shall always have to provide sheds and shops.

Of course, along the coast, lakes and rivers flying boats today can always find a landing place except in times of bad weather, but they cannot find gasoline or repair shops wherever they choose or find it necessary to land. The water flying has that much of a start on land flying but it also has its limitations.

Throughout a large part of the country it is possible to fly regularly less than 300 days out of the year under present conditions. But the remaining days are essential to successful commercial air service. Without regularity commercial aviation cannot really succeed. Therefore, the problem of overcoming bad weather conditions confronts us. That is the work for the Weather Bureau, combined with wireless service which the Army and the Navy have been perfecting. Weather stations at intervals along the air routes, ready to give wind currents and weather conditions at any time to air travelers by wireless telephone, will do much toward increasing the number of days that ships can fly. The one great problem seems to be landing in fogs and snow and storms. Apparatus has already been developed whereby machines can land safely if the fog or clouds hang as low as a few feet above the earth. Local fog dispelling devices are considered feasible. When the Weather Bureau has established an aerial organization and landing in rains and fogs is made safe the flying days will be increased to nearly the limit.

Air navigation above the clouds is another art as yet in the early stages of development. Successful commercial service depends on it. Moreover, flying cannot be confined to the day. Until it is made as safe and certain for night it will not come into its own. Here is another great piece of work to be done, lighthouses along all the air routes.

Proposed Department of Aviation

At the present moment a Department of Aviation wave is in the ascendancy. No concrete plan has been put forward. Moreover, there are many difficult questions to be carefully thought out and definitely answered before we take this step.

Suppose a Department of Aviation is eliminated from the possibilities, then we must seek some other method to control and encourage aeronautics. The nearest analogy that we have to air travel is water navigation. The Government control of shipping, carrying out the laws, inspection and licenses has been fairly satisfactory. Those who do not believe in either

of the other plans profess to see in a Bureau of Aviation under the Department of Commerce or some other department, the solution of the problem. Everyone sees that the greatest danger now lying ahead of aviation development is the lack of proper laws and licenses. If the states start a career of individual law making and licensing, an almost insurmountable obstacle will be put in the path of progress. The air is essentially national, if not international, and state control would certainly hold us back for years—even as state control of railroads has held back the transportation in certain states and consequently held back the state and its neighbors. The physical development of the airship and its physical accessories will naturally go forward unless it is completely checked by criminal carelessness regarding legislation. The British have carefully worked out a set of laws governing the uses of the air; the French have done the same and an international code is being drawn up. It is our natural duty to join in any international agreement. However, our conditions are not entirely analogous to those of Europe and a careful study of our needs and requirements is immediately necessary. Such laws as are drawn up should be as few and as all-embracing as possible, for aviation is going forward with such leaps and bounds that many changes both in the reading and interpretation of the laws will be necessary. The essential thing that needs to be passed now and made hard and fast is that the licensing of all flyers and the regulation of all air travel is a Government job and not a city or State job. Without that, neither the manufacturer nor the commercial company can have positive assurance of future unimpeded development.

The Department of Commerce, on a similar plan to its licensing, inspection, and control of navigation, can organize a bureau from the ex-Army and Navy men and manufacturers to carry on such a work for aviation. If intelligently done, that should be the sole function of the Government except to act in an advisory capacity for State, municipal and private enterprise and to establish and own a bureau of technical research and an educational organization for the public. This bureau would also cooperate with the other nations in drawing up the international air laws and the methods of enforcing them.

Meanwhile there is still before us the period in which commercial aviation is to be made a success. During this period, the United States may lose the commercial field, or at any rate the international field, if nothing is done to foster and keep the public and capital interested. Interest is not likely to die as long as the many competitive new flights are carried on, such as the trans-Atlantic flight, but this kind of interest is not the one to bring in anything but speculative capital toward the real upbuilding of future aviation. But the Government can carry on certain definite large operations which will not only keep up public interest but will also prove the commercial value of the airplane, stimulate the industry and upbuild the accessories necessary to success.

The Treasury Department operates the coast guard and revenue work of the country. Since the Coast Guard Service was organized thousands of lives have been saved, but it is easily possible to double the number every year by adding to the Service airplane and dirigible patrols. Here is a humanitarian and practical work which it is immediately feasible for the Government to start. And, of course, with it go the stations. The patrol of the Mexican and Canadian borders by revenue officers, and even the search for the "blind tiger" in the mountains of North Carolina can be foreseen in the future.

To the Department of Agriculture falls the duty of properly organizing and operating the weather stations without which aviation cannot reach its maximum efficiency. Ideally there might be, and perhaps it may come in the future, weather stations and "lighthouses" every 50 miles which can give by wireless to passing airships not only the air currents and weather conditions up to 20,000 or 30,000 ft. but also tell them what kind of weather they can expect farther along on the journey.

Most people imagine that a mail car starting for Chicago from New York is crammed to the roof with mail bags. As a matter of fact, a large proportion of the room is given up to sorting the mail, to men, bags and racks. So the capacity of the mail car is cut down, increasing the transportation cost per letter. In addition to this increase, railroad postal clerks work under the disadvantages of a railroad car, increasing the cost of sorting mail considerably over the same work in the great postal terminals with all their modern conveniences.

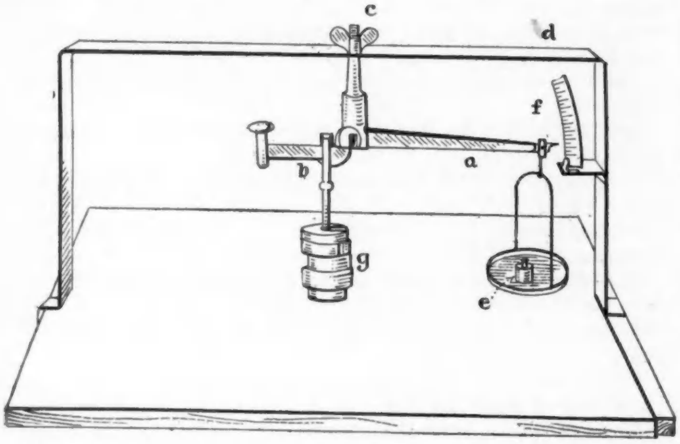
This fact has a direct bearing on the airplane. Suppose regular postage mail can be carried from New York to Chicago in less than half the time it takes by train. It can be sorted at the terminals and still beat the railroad time and compete financially with the railroads.

Approximately 40 per cent of the United States has been surveyed by the Coast and Geodetic Survey. This work, except in the mountainous regions, can now be done photographically from airplanes. The cost will be less than the present survey work and more accurate in every respect. This enormous piece of work that the Survey has been doing for years can be, by comparison, quickly completed. There are two ways of doing it; one is to use the Army and Navy air services during times of peace as the Army and Navy engineers have been used by other departments, and the other is to allow private commercial firms to bid for the work in certain localities.—Frank C. Page in *The World's Work*.

Tautometer for Testing Doped Surfaces[1]

THE power of tautening varies with different dopes; hence the necessity for the tautometer, which should measure the degree of tautness brought about by the particular dope or covering employed. Until recently the tautness was simply more or less guessed, the method usually adopted being to merely tap the doped fabric and deduce the tautness from the note produced. The higher the note, the greater the tautening power of the dope was assumed to be.

The function of a tautometer is to measure the effect of a depressing force, usually exerted by applying a known weight to the center of a known area of doped fabric. This tautness determination is a measurement of at least two important factors of the dope, *i.e.*, the tension or state of strain given to the doped fabric and the flexibility of the dope film.



A TAUTOMETER FOR TESTING SMALL PORTIONS OF A DOPED SURFACE WHICH EMPLOYS THE PRINCIPLE OF A BALANCE WITH A RATIO OF LEVERS THAT PROVIDES FOR A MAGNIFICATION OF ANY DEPRESSION OF THE SHORT ARM

The method of tapping has proved to be both inaccurate and misleading. For instance, a hard film is frequently obtained when an acetyl dope is employed and the doped fabric sounds tauter than measurement with a reliable tautometer proves it to be. In reality a high note frequently indicates a hard and brittle film which will have a great tendency to crack on exposure.

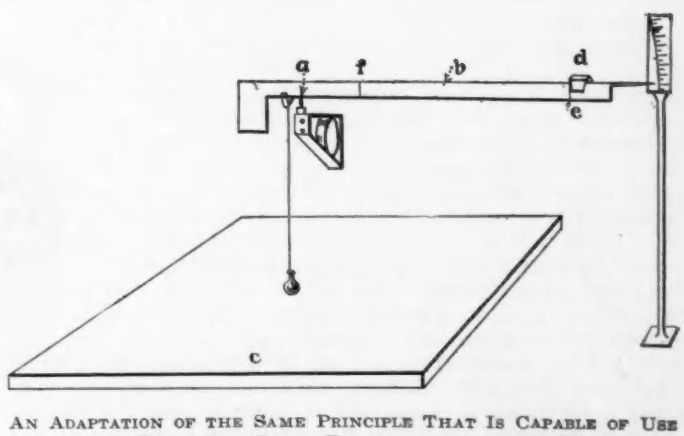
There are various types of instruments for measuring tautness now in use; one, for example, consists of a heavy round-bottomed framework, having a pivot through the center attached to a spring on the upper side, which, in turn, is connected with a pointer. Except for a knob fixed to the lower end of the pivot, only the outer rim of the round bottom of the instrument touches the doped fabric. This instrument is placed on the frame to be measured, and according to the tautness of the doped fabric the knob at the end of the pivot is pushed upward to a greater or less extent, thus compressing the spring and moving the pointer to a position which may be read off on a circular scale. This instrument has many disadvantages, the chief of which is that the tautness of only the small portion of the doped fabric enclosed by the rim of the instrument is measured. Also, the whole weight of the tautometer rests on the doped fabric, and that is obviously no small factor in its disfavor.

The tautometer shown is based on the principle of a balance with a 10 to 1 beam or any other convenient ratio, so that the deflection of the long arm *a* can be magnified for a slight depression of the other *b*. The beam is suspended on a knife-edge in the ordinary way, except that the support is connected with a screw *c* which is used to adjust the beam to any height required. This screw also serves to fix the whole apparatus to a framework *d* which fits over the frame to be measured in such a way that the specified weight, 400 g. having been adopted in the case of the instrument described, is suspended from the short arm, exactly over the center of the frame. This weight is compensated by a 40-g. weight *e* in the scale pan, suspended from the long arm *a*.

When this tautometer is placed on a frame the reading of the pointer at the end of the long run should be at zero on the curved scale *g*, attached to the framework at the right side. If this is not the case the necessary adjustment can be effected by turning the screw *c* in the direction required either to raise or lower the beam. When this has been done the 40-g. weight should be removed from the scale pan. This causes the 400-g. weight *g*, which till now has been just touching the surface, to rest on the doped fabric, and the depression due to it can be read off by the pointer and scale at the other side. This curved scale can conveniently be divided into graduations representing millimeter or fractional parts of an inch depressions of the 400-g. weight on the doped fabric.

The 10 to 1 beam has the advantage of causing a perceptible deflection of the pointer for only 1-mm. depression of the weight, and it must be understood that the smallest deflections are caused by the tautest frames.

A simple adaptation on the same principle has also been used for much larger frames and might with advantage be employed for airplane wings. In this case all framework is dispensed with, except for the bracket used in supporting the knife-edge *a* of the beam *b*. This is fixed to the wall at a convenient height and should stand out half-way across the frame *c* or the wing to be measured, so that the weight to be used for determining the tautness can be arranged to touch the center of the frame. The beam itself should be counterpoised, as before, so as to give a long arm and a short one, when in equilibrium on the knife-edge. Then, as in the previous case, a heavy load is suspended from the short arm to test the tautness of the doped fabric, but instead of having the compensating weight in a scale pan, a sliding



AN ADAPTATION OF THE SAME PRINCIPLE THAT IS CAPABLE OF USE IN THE TESTING OF LARGE FRAMES AND AIRPLANE WINGS

[1]From an article by T. W. H. Ward in a recent issue of *Aeronautical Engineering*.

weight *d* has been adopted, which is placed directly on the beam. When a reading is taken, the weight is slid from the marked position of equilibrium *e* to another one *f* nearer the knife edge, so calculated as to allow the necessary load to rest on the doped fabric. The reading of the pointer on the curved scale can then be noted as before, to show the depression of the doped fabric caused by the weight of the load.

ACTIVITIES OF S. A. E. SECTIONS

At the present time practically all of the Sections have either commenced active work for the season or will do so shortly. The Pennsylvania Section held its opening meeting at the Engineers Club in Philadelphia, Sept. 25. Both the Detroit and Cleveland Sections held meetings the following night. At the meeting of the Cleveland Section at the Hotel Statler a paper on The Use of Aluminum in Present and Future Motor Cars was presented by Ferdinand Jehle, dynamical engineer of the Aluminum Castings Co., Cleveland. The speaker at the Detroit Section meeting at the Hotel Ponchartrain was Captain O. Koester, who described the repairs which the Navy Department made by the welding process on the interned German vessels.

Among the meetings scheduled for the month of October are one of the Minneapolis Section on the 1st and a meeting of the Detroit Section on the 24th.

The Metropolitan Section will hold its first meeting on Oct. 9, and a paper on Gear Transmission will be presented by H. C. McBrair. It is the intention of the Section to hold its meeting on the second Thursday of each month.

The opening meeting of the season of the Buffalo Section will be held on Oct. 21. It is expected that John Younger, assistant to the president of the Standard Steel Car Co., Pittsburgh, Pa., will address the meeting.

The Indiana Section will hold its first meeting for the coming season on Oct. 10. Edward A. Deeds, president, Domestic Engineering Co., Dayton, Ohio, will be the speaker.

A complete list of the secretaries of the different Sections is given below:

Buffalo—Roger Chauveau, 1100 Military Road, Buffalo, N. Y.

Cleveland—A. E. Jackman, 1900 Euclid Avenue, Cleveland, Ohio.

Detroit—Ralph H. Sherry, 1361 Book Building, Detroit, Mich.

Indiana—W. S. Reed, 1602 Merchants Bank Building, Indianapolis, Ind.

Metropolitan—A. M. Wolf, 114 East Sixteenth Street, New York City.

Mid-West—C. S. Rieman, Sixty-first Street and Archer Avenue, Argo, Ill.

Minneapolis—C. T. Stevens, 13 South Ninth Street, Minneapolis, Minn.

Pennsylvania—G. W. Smith, Jr., 309 Hillside Avenue, Jenkintown, Pa.

An effort is being made to avoid conflicts between the various Section Meetings, and the following list gives the days that have been definitely adopted up to the time of going to press:

Cleveland—Third Friday.
Detroit—Fourth Friday.
Metropolitan—Second Thursday.
Minneapolis—First Wednesday.
Pennsylvania—Fourth Thursday.

EXPERIMENTAL WORK ON OIL SHALES

Because of the great quantity of oil contained in the extensive shale deposits of the United States it has been the opinion of many engineers that the recovery of this oil can be profitably undertaken. A bill has been introduced in the Senate proposing to provide the Bureau of Mines with $140,000 for experimental work on oil shales. The Secretary of the Interior has advised the Senate Committee on Mines and Mining that the plan for the proposed research work is necessary to ascertain the most profitable way of recovering the oil and that the bill has his complete approval.

A large initial outlay of capital will be necessary in any projects organized to get commercial oil in this way because an extensve manufacturing process is involved. The importance of accurate and extensive preliminary research work is therefore evident.

It is contemplated that a supplemental appropriation of about $70,000 per annum will be required to carry on the necessary research work.

EFFECT OF MASS ON HEAT TREATMENT[1]

WITH the information now available it is possible to determine the theoretically correct heat treatment for any steel. The practical treatment of large masses of steel, however, presents many difficulties that do not exist in the case of small masses, and various questions at once arise, such as how long does it take for the mass to become uniformly heated in the furnace, to what depth does the effect of oil tempering extend, and to what depth is it possible effectively to harden steel by quenching in water?

In the experiments forming the basis of this paper an ingot 25 in. square and 10 ft. long, weighing nearly 10 tons was cogged down to 18 in. square and cut into 18-in. lengths, thus giving a number of 18-in. cubes, each weighing about 14½ cwt. Only those cubes representing the soundest part of the ingot were employed. Then thermocouples were inserted in each cube, in holes ⅛ in. in diameter, and carefully plugged in position with asbestos. One thermocouple was placed in the center, one halfway between the center of the cube and the center of one side and ¼ in. deep in the center of one surface. These couples were inserted before the cube was placed in the furnace and remained in position throughout the treatment, continuous records being taken. The cubes were placed in a gas-fired furnace at a temperature of 1650 deg. fahr., and that temperature was maintained. The heat penetrated to their centers with remarkable rapidity. After 130 min. the temperature at the center and halfway was almost the same, though at this point the absorption of heat due to the calescence caused a greater lag at the center than elsewhere and the two temperatures did not approach one another again until after another 70 min.

Phenomena of Cooling

After about 4½ hr. the cubes attained a uniform temperature throughout, practically that of the furnace. When this stage was reached one of the cubes was withdrawn and placed on knife edges to cool in the air. Cooling took place very slowly and the evolution of heat was most marked in the center of the mass. A second cube was plunged in oil and, since a large volume of oil was used, the cooling was rapid. In the center the evolution of heat at the point of recalescence was very noticeable but in the halfway curve there was no indication of recalescence.

A third cube was cooled by spraying water at a pressure of 10 lb. per sq. in. on the upper and lower faces. The cooling was more rapid than in oil. The curve of the center again showed an evolution of heat and was not unlike the oil-hardening curve, though the rate of cooling through the lower ranges of temperature was more rapid. The halfway curve, however, was totally different. There was no sign of recalescence in the upper range and the temperature fell evenly to about 450 deg. fahr., when there was a sudden acceleration in the rate of cooling, followed by an equally abrupt halt at about 250 deg. The curve for the cooling of the outside of the cube showed somewhat similar features. In an experiment in which the cube was plunged into water at 55 deg. the cooling was somewhat more rapid, but the curves showed exactly the same characteristics.

The important difference between cooling in oil and in water was the almost sudden slowing up of the cooling with the former in the lower ranges of temperature, as compared with the cooling in water. The time required for the center to cool from 1650 to 1000 deg. was almost the same whether oil or water was used, but in cooling from 1000 to 600 deg. the cube in oil required twice the time and from 600 to 300 deg., nearly four times as long. The differences were even greater for the outside of the cube. Both in oil and water there was a period in which the metal in the center was cooling more rapidly than that midway between center and surface.

Mechanical Tests

From each of the experimental cubes, after cooling, a section 1 in. thick was cut through the center and from this section thirteen test pieces were machined, so that mechanical tests could be made on metal representing the steel from the outside to the center of the cube. The thirteen results from the air-cooled cube were practically identical. In the oil-quenched cube the breaking stress and yield were both raised, while the elongation was lowered to almost the same extent in every test. In other words, the effect of the oil quenching was as apparent in the center as at the outside. The results obtained by water quenching, however, showed very decided variation from surface to center and was most marked in the case of the cube plunged into cold water.

The abrupt halt in the neighborhood of 250 deg. shown in the curves for the water-cooled samples was totally unexpected. The author gave reasons for supposing that it was not connected in any way with the water but was due to some change in the steel itself, and he recalled some results obtained by previous investigators of the properties of iron and steel at low temperatures, which suggested the possibility of a transformation not hitherto recognized. On carrying out some experiments with 2-in. cubes, the break in the curve at 250 deg. was very noticeable with oil hardening, whereas in the water-quenched cube no break in the curve was observed. Further, the latter cube was too hard to machine and, after grinding and polishing, was found to possess a martensitic structure, while the oil-quenched cube was readily machined and possessed a pearlitic structure. Repeated experiments on quenching at different rates showed that whatever the rate of cooling through the higher ranges of temperature down to 572 deg. no appreciable hardening effect was obtained, and the hardening was effective only when the rapid cooling was continued through the lower ranges of temperature.

The Discussion

Cosmo Johns, in discussing the paper, said that the quenching of steel from a high temperature, owing to the volume changes involved, caused the interior to be severely compressed. From known principles it followed that the position of any transformation was altered by pressure, and if the nature of the volume change was known it could be predicted whether the transformation was raised or lowered. In the case of steel, the effect of pressure would be to lower the temperature at which recalescence took place, and this was clearly shown on the cooling curves taken from near the surface and halfway toward the center.

Sir Robert Hadfield said the author referred to some experiments of his own in connection with the spontaneous generation of heat. He was glad to say that those investigations were being pursued, and he believed some very interesting results would be obtained. Without a doubt there was a spontaneous generation of heat at the critical temperature; in fact, at a slightly lower temperature than that to which the author referred.

G. S. Heaven raised the question whether Mr. Law had any experience on the bearing of the phenomena which he had discussed on the question of the cracking of hardened steel? In 1914 his company had considerable trouble in hardening formed cutters of rather intricate design; they either cracked during the hardening operation or immediately afterward, or failed very quickly in work in the shops. He tried all kinds of treatment to get over the trouble and complained very seriously to the steel manufacturer, but that did not do any good. Finally a colleague of his, J. A. Thompson, was convinced that, whatever the cause of the trouble was, it lay somewhere in the low-temperature regions, and they developed the following practice: The tool, previously normalized, was hardened by immersion in water for a number of seconds, depending on the size and shape of the par-

[1]Abstract of a paper presented at a recent meeting of the Iron and Steel Institute (London) by E. F. Law.

ticular tool in question; it was then immediately plunged into oil and cooled off.

H. H. Ashdown said that about 10 yr. ago, during the quenching of heavy gun forgings, efforts were made at Woolwich to record the fall in temperature through the critical ranges, but he did not think that any data had been published. In quenching out large masses of varying section, such as heavy gun forgings, he had often noticed at least three distinct vigorous disturbances of the oil at marked intervals, corresponding with periods of evolution of heat, and it would be very interesting to learn what took place there. Another point which appealed to him was the value which might be obtained from forgings quenched in oil down to approximately the low critical point and then withdrawn quickly and quenched in water.

E. H. Saniter said that a great many years ago he had discovered that if a small piece of steel were taken and reheated for a certain length of time to 250 deg. some remarkable results were obtained, which he attributed to the state of strain, and he found in later years that the fact which he discovered about 10 yr. ago had been of the greatest practical value. In many steels in the ordinary heat-treated condition, or even in the raw condition, the metal was in a state of stress, and by reheating to a comparatively low temperature that stress could be got rid of, and the steel remarkably improved. He was speaking of small pieces, because the same thing did not apply to masses. It appeared to him possible that the evolution of heat was due to the creation of a state of stress in the steel, and if that evolution could be suppressed the steel might be obtained without stress.

The Author's Reply

E. F. Law, replying to the discussion, wished in the first place, as a practical man, to take Cosmo Johns to task for suggesting theoretical explanations which did not fit in with practice. Of course, the obvious explanation of the low point was a depression of the critical point, as would occur to anybody at first sight, but when he came to look into it he found that that explanation would not fit in with the facts, and Mr. Johns would have to find another explanation. Cracking of hardened steels occurred frequently, and he believed it had not been unknown in shells. It occasionally happened that hardened articles broke down for no apparent reason some considerable time after they were hardened, and it was just possible that the low point, or points, had some bearing on the question. With regard to Mr. Ashdown's remark that the small cubes were not comparable with heavy forgings, he really believed they were. Eighteen inches was a very remarkable thickness for any forging. He purposely did not deal with gun forgings, armor plates or any of those things, in the paper; partly because he doubted whether he would have been allowed to publish the paper, but mainly because he wanted to get elementary data on fixed and uniform sizes.—*The Iron Age.*

AMERICAN AUTOMOBILES ABROAD

THE total value of American automobile exports including passenger cars and commercial vehicles amounted to $79,047,767 in the fiscal year ended June 30, 1919, while the exports of parts and tires totaled $25,650,810 more. The total value of automobile exports for the year was over two and one half times that of the fiscal year ended June 30, 1914, the number of passenger cars exported in the last fiscal year being 45 per cent greater than in 1914 while their value was 80 per cent more. The exports of automobile tires showed an increase in value of five times that for the fiscal year ended June 30, 1914. The number of commercial cars exported in the last fiscal year was fifteen times as great as that for the year ended June 30, 1913, while the value was twenty-eight times as great. Some idea of the volume of business done is indicated by the statement that one automobile was exported from the United States on an average of every 9 min. of each night and day including Sundays and holidays. Foreign purchasers spent on an average of $264.26 every minute of the day and night for automobiles and parts including tires. Of this sum $43.05 was spent for tires while the expenditure for magnetos, spark-plugs, etc., was $5.93.

Some of the foreign countries spent almost as much for tires as they did for the vehicles themselves. In the case of the Argentine for every dollar expended in the purchase of automobiles the tire manufacturers received an additional 82 cents. The value of the tires purchased by the inhabitants of that country in the past fiscal year was 83 times that of 1914. The value of the tires exported to Brazil was 56 times as great as in 1914 and in the case of Chile this was 106 times as large as in 1914. For every dollar that the inhabitants of the latter country spent for automobiles approximately 70 cents additional was paid for tires. This condition is true not only of South America but other parts of the world. For example the value of tires exported to the Dutch East Indies was 303 times that of the exports for the fiscal year ended June 30, 1914, and for British India, 131 times that of the earlier year.

Estimates of the number of cars in the principal foreign countries on June 30, 1919 have been compiled from official statistics of automobile registrations and licenses and import, export and production figures of various countries. The results which are believed to be approximately correct show that the total number of cars was 1,384,259. Great Britain heads the list with 415,000, while British Honduras is at the other end with only 50. Canada has second place with 300,000 cars and France is third with 200,000. Germany and Italy follow with 75,000 and 35,500 respectively. Argentina and Australia are credited with 25,000 each and Cuba and the Netherlands rank next with 20,000.—*The American Exporter.*

PERSONAL NOTES OF THE MEMBERS

H. Leroy Beaver has resigned as steel ball sales manager with the SKF Industries, Inc., New York City.

Forrest E. Cardullo has accepted a position as chief engineer with the G. A. Gray Co., Cincinnati, Ohio.

George B. Carpenter has severed his connection with the Davis Sewing Machine Co., Cleveland, Ohio, and will engage in the practice of consulting engineering at Ithaca, N. Y.

John Cetrule who was formerly stationed at the plant of the Wright-Martin Aircraft Corporation, Long Island City, N. Y. as an inspector in the aviation section of the Signal Corps has been transferred to Camp Nyssa, Farmingdale, N. Y., where he is serving in the motor transport division of the Reserve Officers' Training Corps.

D. Edwin Gamble has severed his connection with the production engineering department of the Willys-Overland Co., Toledo, Ohio, and has assumed charge of the engineering and experimental work of the Borg & Beck Co., 914 South Michigan Ave., Chicago, Ill.

W. E. Hamilton has accepted a position as mechanical and efficiency engineer with the Adamson Mfg. Co., East Palestine, Ohio. He was formerly assistant production director with the Standard Parts Co., Cleveland, Ohio.

Hiram F. Harris has been appointed general manager of the Bethlehem Motors Corporation, Allentown, Pa. He was formerly associated with the All American Motor Truck Co., Chicago, Ill.

J. W. Hobbs, who was in command of an ordnance repair shop with the A. E. F. in France, has been discharged from the Army with the rank of captain and has been placed in charge of the truck and tractor experimental laboratory at the Rock Island Arsenal, Rock Island, Ill.

George H. Keagy has resigned as production engineer with the New York Shipbuilding Corporation, Camden, N. J., and has accepted a position with the Indiana Piston Ring Co., Hagerstown, Ind.

Henry B. Landau has resigned as general foreman of the assembly and test department at the Sandusky, Ohio, plant of the Wright-Martin Aircraft Corporation, and is now superintendent of manufactures at the Bridgeport works of the Remington Typewriter Co., Bridgeport, Conn.

Herman G. Muelke has accepted a position as instructor of design at the Buffalo Technical High School, Buffalo, N. Y. He was formerly connected with the Pierce Arrow Motor Car Co. of that city as a designer.

Thomas T. O'Brien has been appointed manager of the motor truck department of the Olds Motor Works, Lansing, Mich.

J. P. Oliveau sailed Sept. 20 to visit the automobile show at Paris.

E. R. Pendleton has resigned as chief tractor engineer with the Engel Aircraft Co., Niles, Ohio, to accept a position with the Superior Tractor Co., Cleveland, Ohio.

J D. Reid, who has been attached to the technical section of the Air Service at Paris, has been discharged from Government employ and has accepted a position with the engineering force of Brewster & Co. He is stationed at their factory at Long Island City, N. Y.

Arthur J. Slade has been discharged from the army with the rank of Lieutenant-Colonel after 2 years' service. His service in this country included the engineering work in connection with the design and production of motor transport vehicles for the Air Service and the training of operating and maintenance personnel. In the A. E. F. he organized and directed the engineering division of the Motor Transport Corps, served as a member of the International Armistice Commission and made a collection of German military trucks of all types for engineering research by the War Department. It was a portion of this collection that was exhibited at the recent Summer Meeting of the Society. Mr. Slade has resumed his practice as a consulting engineer in motor transportation with offices at 1790 Broadway, New York City.

Pierce G. Smith, formerly sales manager of the American Malleable Co., Lancaster, N. Y., has been elected vice-president.

O. E. Szekely has resigned as engineer and production manager of the tractor department of the Velie Motors Corporation, Moline, Ill., and has organized the O. E. Szekely Co., with offices at 202 Safety Building, Rock Island, Ill. He is president and chief engineer of the organization which specializes in designing and consulting mechanical and automotive engineering work.

Chance M. Vought has been elected a director of the United Aircraft Engineering Corporation, New York City.

George R. Wadsworth has been elected second vice-president and a director of the United Aircraft Engineering Corporation, New York City. During the war he was chief engineer of the Naval Aircraft Factory at League Island Navy Yard, Philadelphia, Pa., and in his new position he will have charge of the transportation development work which includes the establishment of municipal landing fields and air routes in all parts of the country for carrying passengers and light express traffic.

H. G. Weaver has been placed in charge of the sales promotion department recently established by the Hyatt Roller Bearing Co. at Chicago, Ill. For the past year he has spent his entire time in the field with farmers and dealers in power farming machinery making an investigation of the conditions which exist.

Wayne H. Worthington has resigned as chief engineer of the Electric Wheel Co., Quincy, Ill., to accept a similar position with the Aultman-Taylor Machine Co., Mansfield, Ohio.

Current Standardization Program

THE active work of the Standards Committee for the coming season was inaugurated on Sept. 16 when a meeting of the Iron and Steel Division was held at the Society headquarters in New York City.

Iron and Steel Division

At this meeting the report on high-chromium steel which appeared in the September issue of THE JOURNAL was discussed. It was voted to submit this report to the Standards Committee as an appendix to the next Iron and Steel Report, recommending that it be published in the Handbook as general information only. In this connection it should be noted that the steel designated as *A* in the chart of scaling tests on page 262 of the September issue of THE JOURNAL should be 0.3 per cent carbon steel instead of 3 per cent as given in the legend.

The question of adopting a low-tungsten valve steel such as is covered by Signal Corps Specification No. W60b was discussed.

The analysis of this steel is as follows:

	Per Cent
Carbon	0.500 to 0.700
Manganese	0.300 (maximum)
Phosphorus	0.035 (maximum)
Sulphur	0.035 (maximum)
Chromium	0.500 to 1.000
Tungsten	1,500 to 2.000

The discussion of this subject brought out the opinion that the Division did not have sufficient information on which to base any definite action and it was voted to table the subject of a low-tungsten valve steel until the engine and valve manufacturers could be circularized and their practice ascertained.

British Standardization Situation

C. Le Maistre, secretary of the British Engineering Standards Association, was introduced. He said that he brought the very cordial greetings of his association and especially of the Institution of Automobile Engineers and then informally discussed the standardization situation in England. He stated in part that the British automobile industry had suffered during the war owing to the operations which the Government made it take up; that nothing like the amount of automobile standardization work that has been done here has been accomplished in Great Britain, and that he hoped for the cooperation of the American automobile industry in the establishment of international standards. Mr. Le Maistre further said that complete international standardization cannot be expected owing to the immense number of details that depend on local conditions, but that with our help many parts and material specifications can be brought into agreement, and that in this work his association which covers all industries will look to the S. A. E. for cooperation.

Nickel-Chromium Steel

It was stated that there is a large consumption of nickel-chromium steel that does not conform to the S. A. E. specifications. It was also stated on behalf of one maker that a 3200 steel should not be used for crankshafts on account of heavy heat-treatment losses through cracking owing to the high chromium content.

During the discussion a suggestion that a table should be compiled giving the equivalent Army, Navy, S. A. E., and English specifications was approved. It was stated that the English aircraft steel specifications are practically in agreement with the French. The advisability of submitting a tentative specification which should be tried out by the industry at large before being adopted by the Division was discussed. It was pointed out that the matter should be decided by consumers and that an earnest attempt should be made to have representative consumers present at the next meeting when the subject could be reconsidered.

Division Policy

It was voted as the sense of the meeting that the Iron and Steel Division should furnish for publication in THE JOURNAL and the S. A. E. Handbook information about all types and uses of new steels coming before the industry.

The suggestion that the Division consider standardizing a cast iron and a 5 per cent nickel steel for valve heads was discussed. It was voted to table these subjects until information could be obtained showing present practice.

It was the sense of the meeting that inasmuch as the Division had discussed thoroughly the question of marking steel stock by colors at the previous meetings, when it was definitely decided that this is impracticable and that each manufacturer should devise his own color scheme, the subject should not be reconsidered as suggested.

It was brought out that malleable iron castings are being used to a considerable extent in automotive construction. It was voted that the Division should recommend the publication in THE JOURNAL and in the S. A. E. Handbook, of the latest malleable iron specification of the American Society for Testing Materials, which has been adopted by the American Malleable Castings Association.

It was the sense of the meeting that all data collected with a view to completing the curves showing the physical properties of S. A. E. steels above 3140 should be put in the hands of the Division chairman. It was suggested that a request should be published in THE JOURNAL for any data which would assist in this work.

A letter from the Ordnance Department, U. S. A., in reference to correlating the various specification numbers was read. It was suggested that the Chairman of the Division should write to the Ordnance, Army and Navy Departments, Bureau of Standards, Treasury Department and different engineering societies requesting their views on the possibility of arriving at a common system of classifying steels. It was the opinion of those present that the idea of incorporating the adoption date in the specification number in some way should receive consideration as this would make it less confusing to the industry when specifications are revised.

Tests of Headlamps

The Sub-division on Headlamp Illumination of the Lighting Division, conducted a series of tests on Sept. 24, at New York City, to verify the revised specifications prepared by the Committee on Automobile Headlighting Specifications of the Illuminating Engineering Society and the Lighting Division of the Standards Committee as to the minimum road illumination which should be required and the maximum glare which should be per-

mitted for automobile headlamps. Opinions were obtained from about twenty-five competent observers.

The results of these tests will be reported by the Sub-division at the next Lighting Division meeting which is scheduled for Nov. 11.

British Tire Standardization

A special meeting of Tire and Rim Sub-Division chairmen was held on Sept. 25 at the Society headquarters, at which the report of the British Rubber Tyre Manufacturers Association that had been submitted to the British Engineering Standards Association for adoption was discussed with C. Le Maistre, secretary of the latter association. Points of dissimilarity between the present S. A. E. Standards and the proposed British standards were brought out and it is hoped that the results of this meeting will make possible the complete correlation of British and American standards.

Tire-Pump Mounting Transmission

In the drawing of the large type tire-pump transmission mounting, shown on page 186 of THE JOURNAL for August, the dimensions at the top should be $4\frac{1}{8}$ and 2 1/16 in. respectively instead of $4\frac{7}{8}$ and 2 7/16 in. as shown. The dimensions of $4\frac{7}{8}$ and 2 7/16 in. at the bottom are correct.

Division Meetings Scheduled

A tentative schedule of various Division meetings during October and November is appended.

Division	Date	Place
Aeronautic	Nov. 3	New York City
Ball and Roller Bearings	Nov. 7	New York City
Chain	Oct. 23	New York City
Electrical Equipment	Nov. 21	Cleveland
Engine	Nov. 19	Detroit
Iron and Steel	Oct. 21	New York City
	Nov. 18	New York City
Lighting	Nov. 11	New York City
Marine	Nov. 10	New York City
Miscellaneous	Nov. 18	Detroit
Motorcycle	Nov. 12	Detroit
Non-Ferrous Metals	Oct. 13	New York City
	Nov. 17	New York City
Shaft Fittings	Nov. 19	New York City
Springs	Nov. 10	Detroit
Stationary Engine and Lighting Plant	Nov. 15	Chicago
Tire and Rim	Nov. 20	Cleveland
Tractor	Nov. 14	Chicago
Transmission	Nov. 11	Detroit
Truck Standards	Nov. 17	Detroit

Applicants *for* Membership

The applications for membership received between Sept. 8 and Sept. 29, 1919, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AUSTIN, R. W., second vice-president, factory manager and engineer, Gramm-Bernstein Motor Truck Co., *Lima, Ohio.*

BLOMQUIST, G. L., draftsman, U. S. Ball Bearing Mfg. Co., *Chicago, Ill.*

BROSSEAU, C. L., export department, International Motor Co., *New York City.*

COPLAND, ROBER Y., mechanical engineer, Dominion Tire Factory, *Kitchener, Ont., Canada.*

CRANE, JASPER E., manager, cellulose division, chemical department, E. I. du Pont de Nemours & Co., *Wilmington, Del.*

DAUGHERTY, R. E., designer, Goodyear Tire & Rubber Co., *Akron, Ohio.*

ECKER, G. J., superintendent and factory manager, Detroit Gear & Machine Co., *Detroit, Mich.*

EMMONS, HAROLD H., attorney, 1301 Ford Building, *Detroit, Mich.*

ENGEL, F. J. C., mechanical engineer, Detroit Gear & Machine Co., *Detroit, Mich.*

FISKE, J. PARKER, president and general manager, Sunnyhome Electric Co. division of General Motors Corporation, *Detroit, Mich.*

GARDNER, FRED. W., vice president for production, Gardner Motor Co., *St. Louis, Mo.*

GAYNOR, HUGH F., layout draftsman, Service Motors Co., *Wabash, Ind.*

GILLES, PIERRE P., consulting and chief engineer, Bastian Blessing Co., *Chicago, Ill.*

GORMAN, THOMAS J., engineer and purchasing agent, Meteor Motors Inc., *Philadelphia, Pa.*

HIGGINS, HOWARD R., draftsman, U. S. Ball Bearing Mfg. Co., *Chicago, Ill.*

JASCHKA, JOHN H., sales engineer, National Malleable Castings Co., *Cleveland, Ohio.*

JONES JOHN J., president and general manager, Jones Motor Car Co., *Wichita, Kan.*

KELLY, RAYMOND J. K., automobile race driver, Thomas Kelly & Bros., *Chicago, Ill.*

KRAEMER, EMIL, engineer, 236 Bay Tenth Street, *Brooklyn, N. Y.*

MACLAREN, ALFRED M., sales engineer, S. K. F. Industries Inc., *San Francisco, Cal.*

MAGNUSON, ROY M., draftsman, Holt Mfg. Co., *Stockton, Cal.*

NICYPER, HENRY R., tool designer, Nordyke & Marmon Co., *Indianapolis, Ind.*

ORR, WILLIAM A. C., draftsman, engineering department, City of Winnipeg, *Winnipeg, Canada.*

PARSONS, BEN G., chief of engineering, Dayton Wire Wheel Co., *Dayton, Ohio.*

POUNSETT, FRANK H., mechanical transport inspector, Canadian Army, Service Corps, *Ottawa, Ont., Canada.*

RAINBAULT, J. P., vice-president and sales manager, Chassis Lubricating Co., *New York City.*

RANDALL, MALCOLM, experimental engineer, Service Motor Truck Co., *Wabash, Ind.*

REPLOGLE, JOHN R., chief engineer, Frigidaire Corporation, *Detroit, Mich.*

RESSEGIUE, O. H., assistant general manager, Jones Motor Car Co., *Wichita, Kan.*

ROSENBLOOM, ABRAHAM, designing draftsman, Minneapolis Steel & Machinery Co., *Minneapolis, Minn.*

SEACORD, CHARLES L., directing manager, Burns Motor Co., *Columbia, S. C.*

SHEAHAN, THOMAS W., layout man, Packard Motor Car Co., *Detroit, Mich.*

SLAUSON, LOUIS F., manager, Grid-Iron Grip Co., *Rock Island, Ill.*

SLONEK, FRANK G., chief engineer, R. M. Hvid Co., *Chicago, Ill.*

STEWART, GEORGE E., draftsman, Holt Mfg. Co., *Stockton, Cal.*

TORGERSON, ALFRED C., partner, Main Street Garage, *Anaconda, Mont.;* engineering manager, Torgerson Brothers, *Billings, Mont.*

TRUSCOTT, STARR, lighter-than-aircraft assistant, Bureau of Construction and Repair, Navy Department, *Washington.*

VANDERVOORT, F. M., chief designer of trucks and tools, Mitchell Motors Co., *Racine, Wis.*

WARD, LOUIS M., secretary and factory manager, Cushman Motor Works, *Lincoln, Neb.*

WHITTINGHAM, RICHARD R., president, American Machine Co., *Newark, Del.*

WILLARD, DONALD E., president, Decatur Malleable Iron Co., *Decatur, Ill.*

WILLIAMS, MAJOR-GENERAL C. C., chief of ordnance, War Department, *Washington.*

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

BARNEY OLDFIELD'S BOOK FOR THE MOTORIST. By Barney Oldfield. Published by Small Maynard & Co., Boston, Mass. Cloth, 4½ by 7¼ in., 260 pages, numerous illustrations.

Facts which owners and drivers of cars should know are presented in a non-technical way in this book. The information is the result of the author's experience as a driver of racing automobiles. The book is intended as a supplement to rather than a substitute for the handbooks which are compiled by the various builders of passenger cars.

The first of the twenty-five chapters deals with the purchase of a new car and gives general directions as to precautions that should be observed. The importance of studying the instruction book provided by the builder as a means of lengthening the life of the car is emphasized in the second chapter. Instructions on breaking-in the new car and the necessity for safe, efficient and economical driving follow with information on how to secure these desired results. What must be done to keep a car in good condition is next brought out with special emphasis upon the importance of lubrication. Instruction is given on the care of the various parts of the car so as to reduce noises, the care of the storage battery and the elimination of starting and lighting and tire troubles. The protection of a car in winter and the proper way to overhaul and store it are described. A chapter on the anti-glare problem and a number of valuable suggestions on driving complete the book.

OFFICE ADMINISTRATION. By J. William Schulze. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth Street, New York City. Cloth, 5¼ by 8 in., 295 pages, 30 illustrations.

This book constitutes a thorough discussion of the principles and methods which underlie efficient and economical office management, the aim having been to present these in such a way that the book will be of value to the student in university business courses, as well as the active executive. As far as possible only general principles are discussed, their application being illustrated, and reproductions of forms and detailed descriptions of systems which cannot be used generally being omitted.

The book is divided into eighteen chapters, the first of which deals with the evolution of the modern office and the functions of business. This is followed by a chapter dealing with the office manager and his duties. The selection and training of office employes are discussed at some length and the desirability of having practice and rules in written form is emphasized. The establishment of routine methods is discussed together with different forms of organization and the formulation of various plans of procedure. The layout of an office with the ventilation, light and partition requirements is described, a typical case of their application to an actual problem being given. A chapter on standardization is included, as well as one on the relationship between the employer and the employe. Order, billing and filing systems are discussed. Two chapters deal with general office service and business correspondence.

IRON AND STEEL. By Hugh Tiemann. Published by the McGraw-Hill Book Co., Inc., 239 West Thirty-ninth Street, New York City. Cloth, 4 by 6¾ in., 514 pages, 66 illustrations.

In bringing out the second edition of this pocket encyclopedia of iron and steel and the allied industries and sciences, the book has been not only enlarged but entirely reset. In the revision the number of terms and the text have been increased approximately one-half. This increase has been due in part to more extended discussion of subjects such as heat treatment, physical properties and testing and numerous investigations of the more theoretical aspects of the subject, particularly those included under metallography. A feature of the new edition is a brief outline of the metallurgy of iron and steel, immediately preceding the text.

The arrangement followed is the same as in the first edition, a combination of a dictionary, an encyclopedia and a handbook. The various terms are arranged alphabetically and the definitions or descriptions of isolated terms or processes are found under their respective headings in the proper alphabetical sequence. Other terms employed in connection with some special subject or process appear in alphabetical arrangement but the descriptions are found under the subject or process, reference in every case being made by page numbers. In all of the definitions the various individual terms mentioned are printed in bold face type.

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